VOL. XXXV. No. 2. FEBRUARY, 1957

2 MAY 5
COPY 1967

THE STRUCTURAL ENGINEER

THE JOURNAL OF THE
INSTITUTION OF STRUCTURAL ENGINEERS



Post-War Developments in German Steel Bridges and Structures
By G. Bernard Godfrey (Associate-Member)

Factory in Concrete for the Pressed Steel Co. Ltd., Stratton St. Margaret
By D. H. New (Member) and R. Sanders (Member)

The Use of Gunite as a Structural Material
Discussion on the Paper by Mr. T. Whitley Moran (Member)

FOUR SHILLINGS

RITECURE

membrane curing

USED FOR CURING

28 MILLION

YARDS OF CONCRETE

IN THE BRITISH ISLES

Ritecure produces an impervious film which provides controlled moisture retention throughout the curing period of 28 days.

Ritecure should be sprayed on the concrete immediately after finishing. Spraying is a one man operation.

Ritecure is complete in itself requiring no covering down or wetting. One coat only is required.

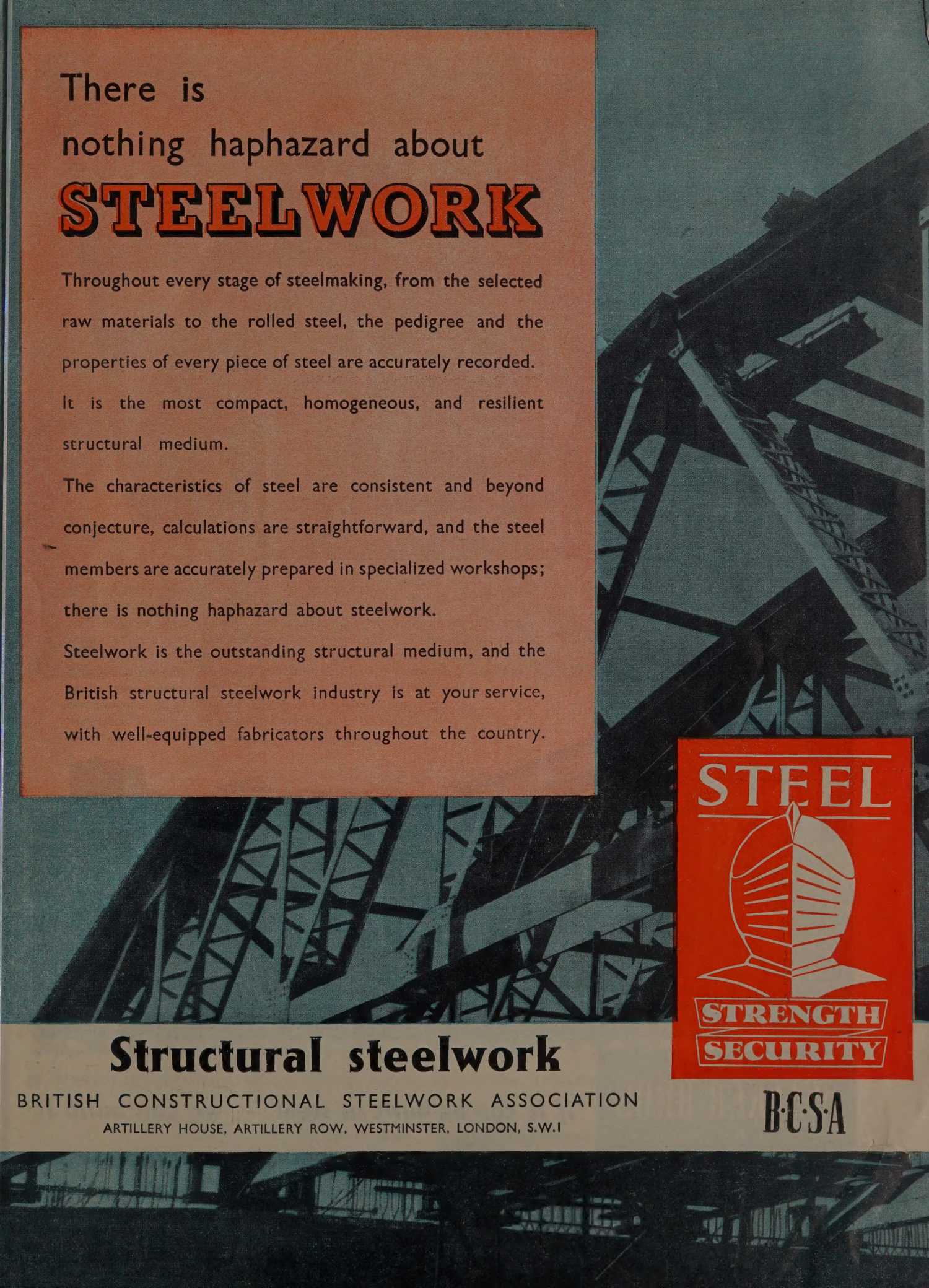
Ritecure. This can be supplied pigmented if required.

Write for our Technical Leaflets and Specifications

STUART B. DICKENS LIMITED

36 Victoria Street, London, S.W.1. Telephone: Abbey 4980

Works: Old Milton Street, Leicester. Telephone: Leicester 20390



There is
nothing haphazard about
STEELWORK

Throughout every stage of steelmaking, from the selected raw materials to the rolled steel, the pedigree and the properties of every piece of steel are accurately recorded.

It is the most compact, homogeneous, and resilient structural medium.

The characteristics of steel are consistent and beyond conjecture, calculations are straightforward, and the steel members are accurately prepared in specialized workshops; there is nothing haphazard about steelwork.

Steelwork is the outstanding structural medium, and the British structural steelwork industry is at your service, with well-equipped fabricators throughout the country.

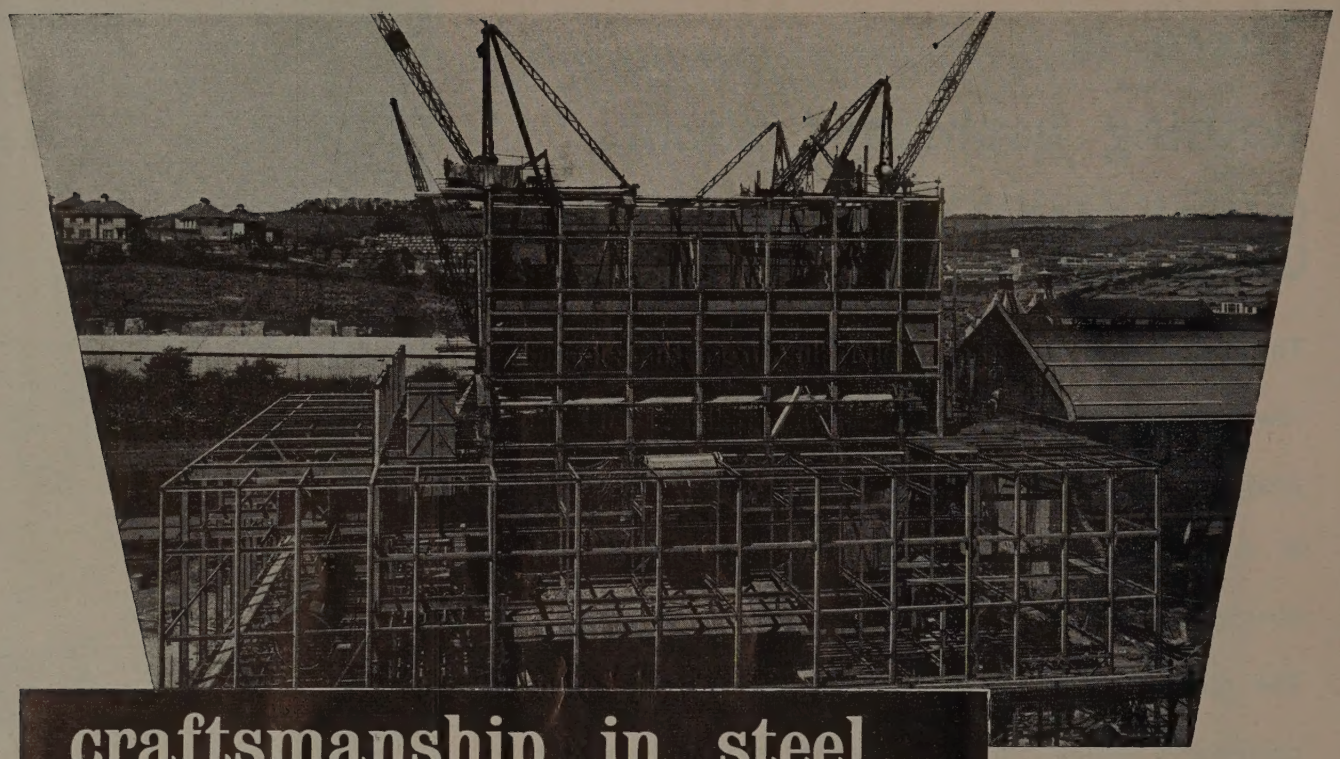
STEEL
STRENGTH
SECURITY

Structural steelwork

BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION

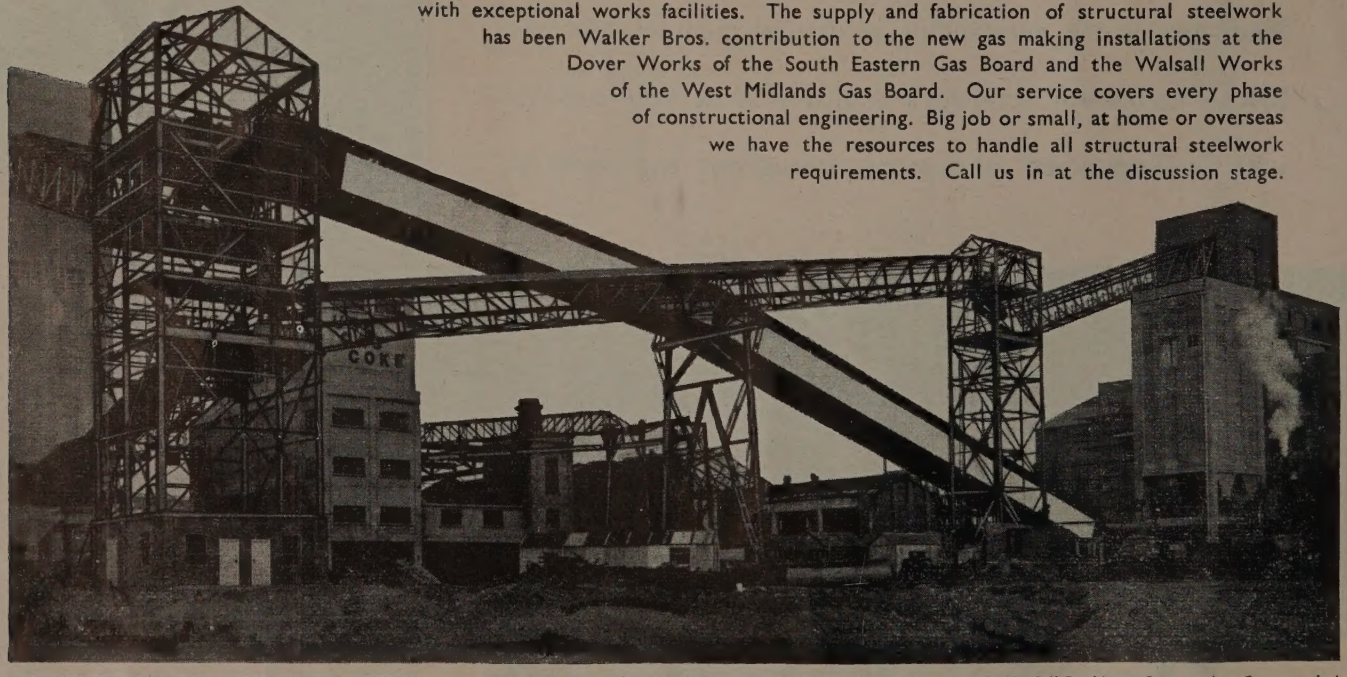
ARTILLERY HOUSE, ARTILLERY ROW, WESTMINSTER, LONDON, S.W.1

B·C·S·A



craftsmanship in steel...

The structures illustrated show developments within the Gas Industry and are yet another fine example of co-operation between experienced planners and engineers, and the resources of an organisation with exceptional works facilities. The supply and fabrication of structural steelwork has been Walker Bros. contribution to the new gas making installations at the Dover Works of the South Eastern Gas Board and the Walsall Works of the West Midlands Gas Board. Our service covers every phase of constructional engineering. Big job or small, at home or overseas we have the resources to handle all structural steelwork requirements. Call us in at the discussion stage.



Photograph by permission of West Midlands Gas Board and Woodall-Duckham Construction Company Ltd.

WALKER BROS
LIMITED
Structural Engineers

if it can be built in steel - we can build it

WALSALL · STAFFS · TELEPHONE: WALSALL 3136

London Office: 66 Victoria Street, S.W.1 - Telephone: VICtoria 3926

ESTABLISHED 1867



THE ABOVE VIEW SHOWS THE WORK IN PROGRESS

the new

DEAL PROMENADE PIER

is being constructed for the Borough of Deal by

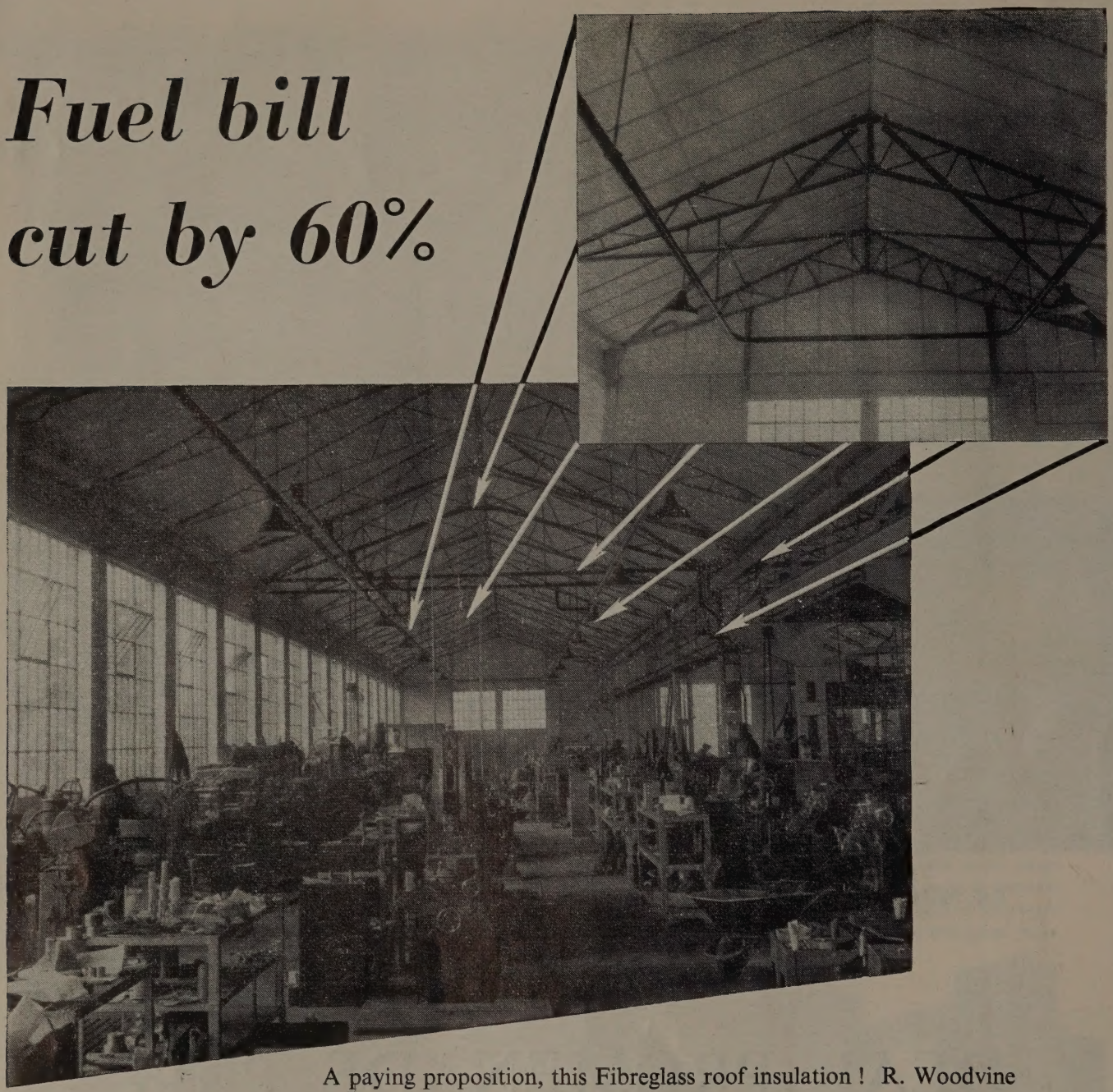
CONCRETE PILING LTD.

10 WESTMINSTER PALACE GARDENS, ARTILLERY ROW, LONDON, S.W.1. Phone: ABBey 1626/7

Specialists in the construction of all forms of reinforced concrete structures for industrial and public authority

Consulting Engineers:
Sir Wm. Halcrow & Partners
MM.I.C.E.

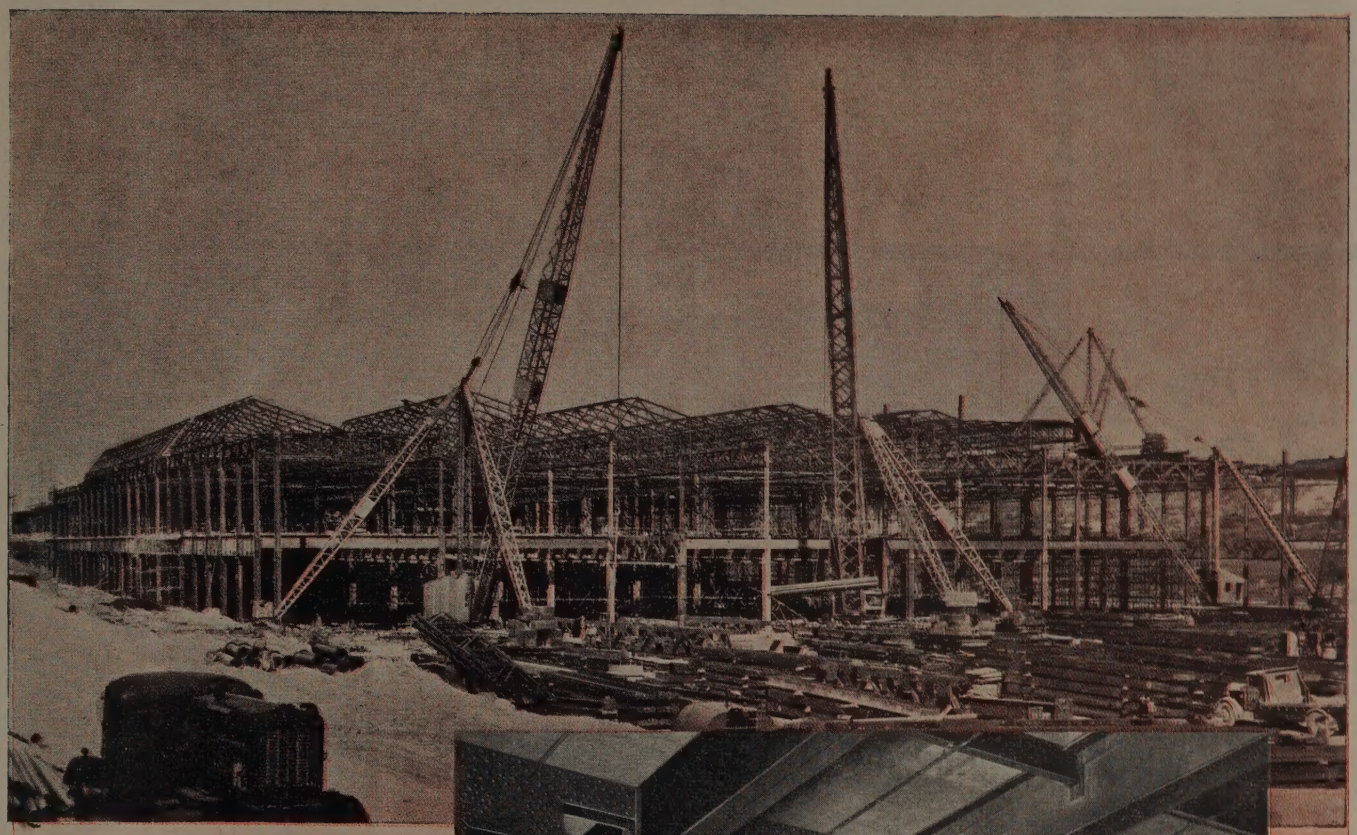
Fuel bill cut by 60%

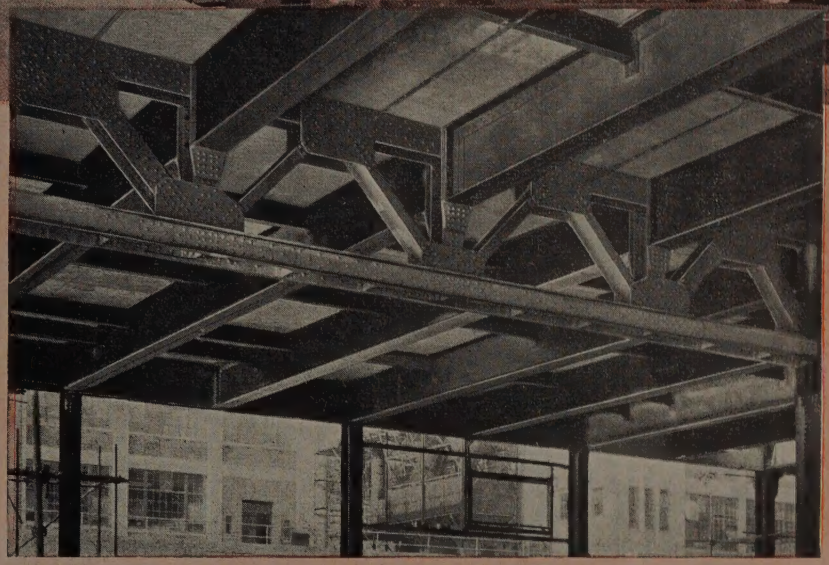


A paying proposition, this Fibreglass roof insulation ! R. Woodvine & Son Ltd. of Shrewsbury have proved it : at their Sundorne Works last winter, it cut fuel bills by 60%. Fibreglass has proved to be a comfort in other ways too : in warm weather, Woodvine's have found that it makes the factory a cooler and more pleasant place to work in. Add the advantages of excellent acoustic insulation, high fire resistance and easy installation — and you have compelling reasons for writing away for the whole story — a story that covers every aspect of industrial insulation, rigid and flexible pipe insulation, boiler jackets, ceiling board and cavity wall filling and many other applications.

Wrap that factory in FIBREGLASS TRADE MARK

FIBREGLASS LTD., RAVENHEAD, ST. HELENS, LANCS. ST. HELENS 4224





VAUXHALL MOTORS LTD LUTON

Extension to Factory

Architects:
Howard Souster & Fairbairn
Consulting Engineers:
G. A. Dodd & Partners
Contractors:
Sir Robert McAlpine & Sons, Ltd.

Approximate total weight 20,000 tons, of which over 17,000 tons were erected in twelve months. The lower illustration shows one of the 168 main girders supporting the assembly floor.

STEELWORK BY

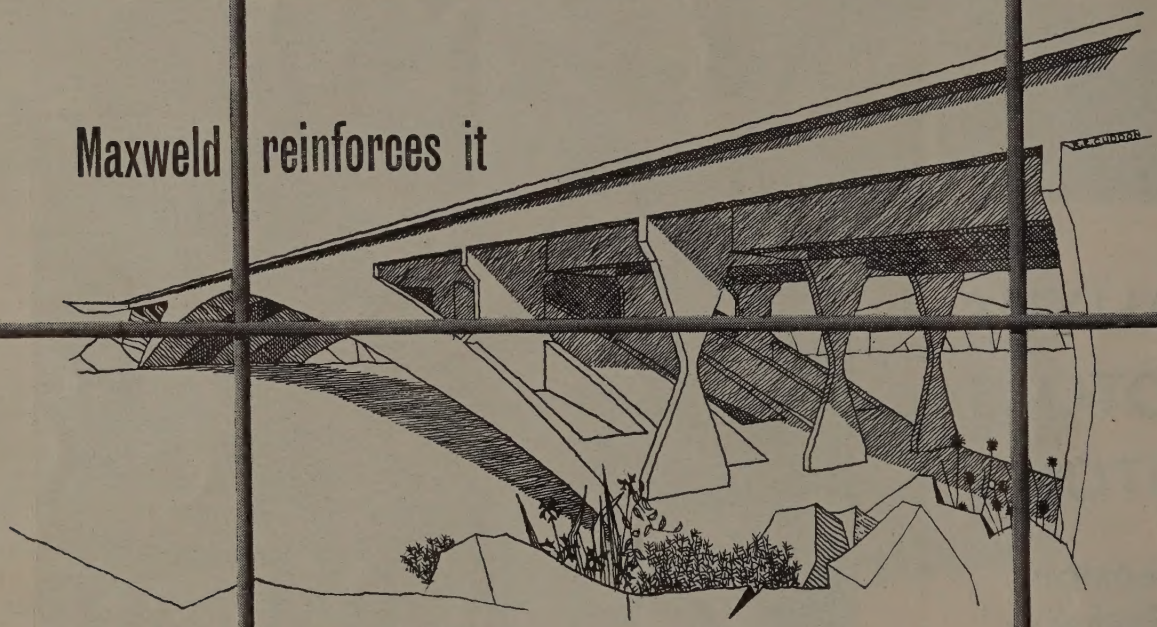
REDPATH BROWN

STEEL STRENGTH SECURITY

LONDON OFFICE: 3 DUNCANNON STREET, LONDON. W.C.2



Maxweld reinforces it



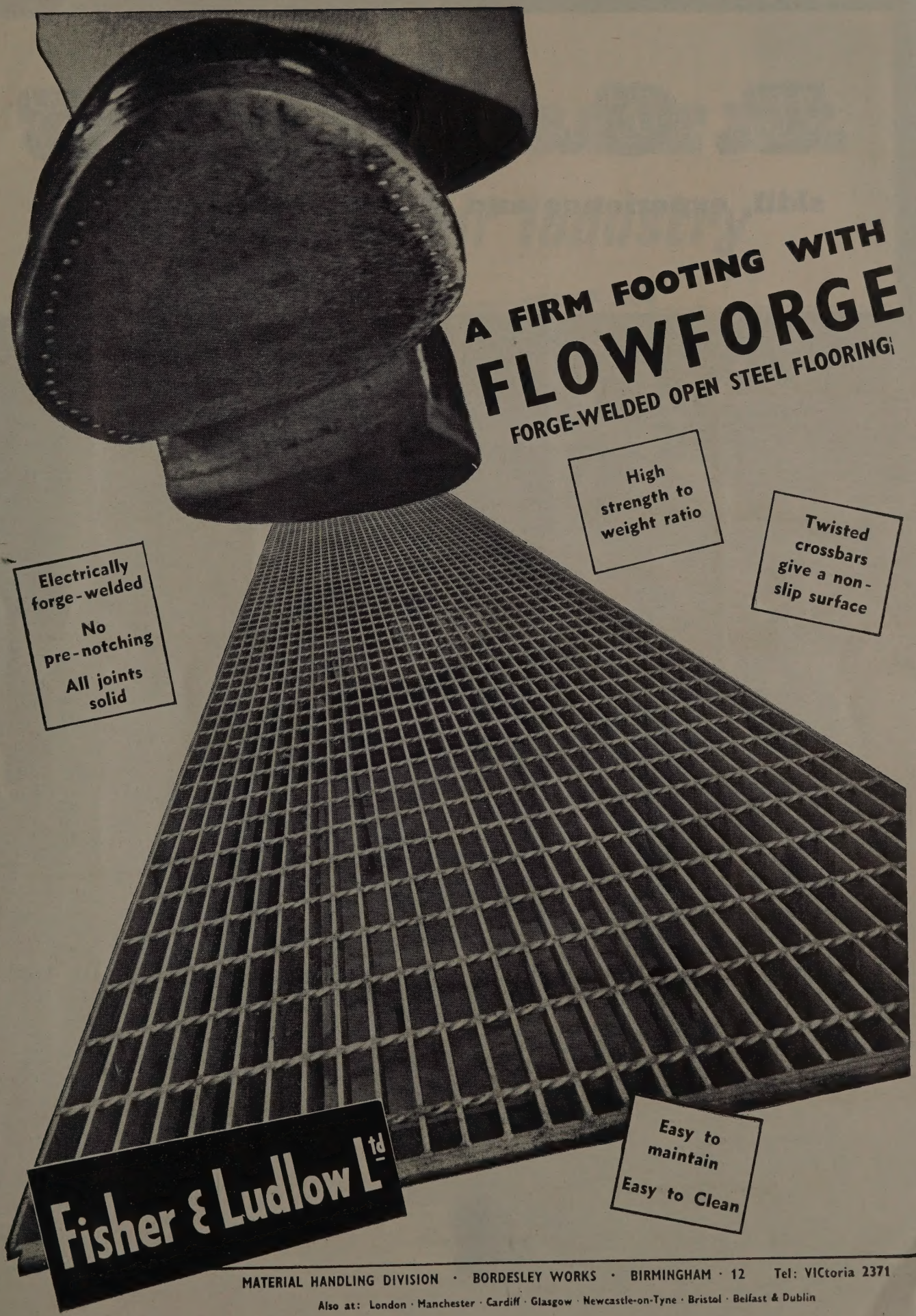
All over the world, MAXWELD reinforces it: concrete and brickwork, in roads, locks, factories, docks, bridges, spas and reservoirs.
Do you need reinforcements? Call up the MAXWELD man!
He'll tell you all about MAXWELD fabric—made to BSS 1221 Part A, closely controlled for quality from raw material onwards, available for quick delivery anywhere. He'll tell you what type you need, how much you need, and how much it's going to cost you. He's backed by *Richard Hill's Design Service*, always ready to work out detailed plans and estimates. Call up the MAXWELD man—at Middlesbrough, London, Birmingham, Manchester, Leeds, Bristol and Glasgow.

Maxweld fabric

is manufactured by **RICHARD HILL LIMITED** (Established 1868)
Newport Wire and Rolling Mills, Middlesbrough, Yorkshire. Tel: Middlesbrough 2206

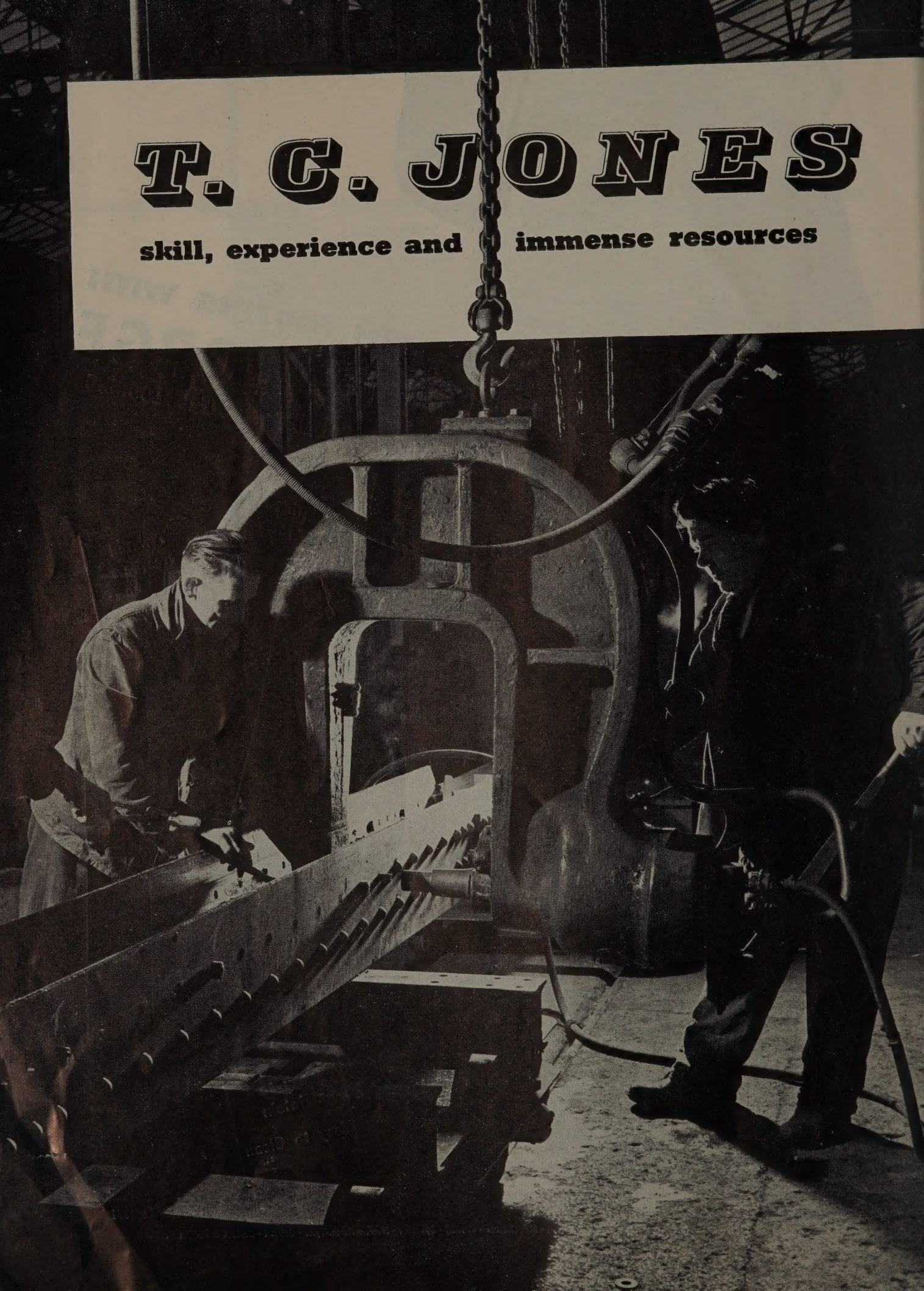
A MEMBER OF THE FIRTH CLEVELAND GROUP

CRC IMX



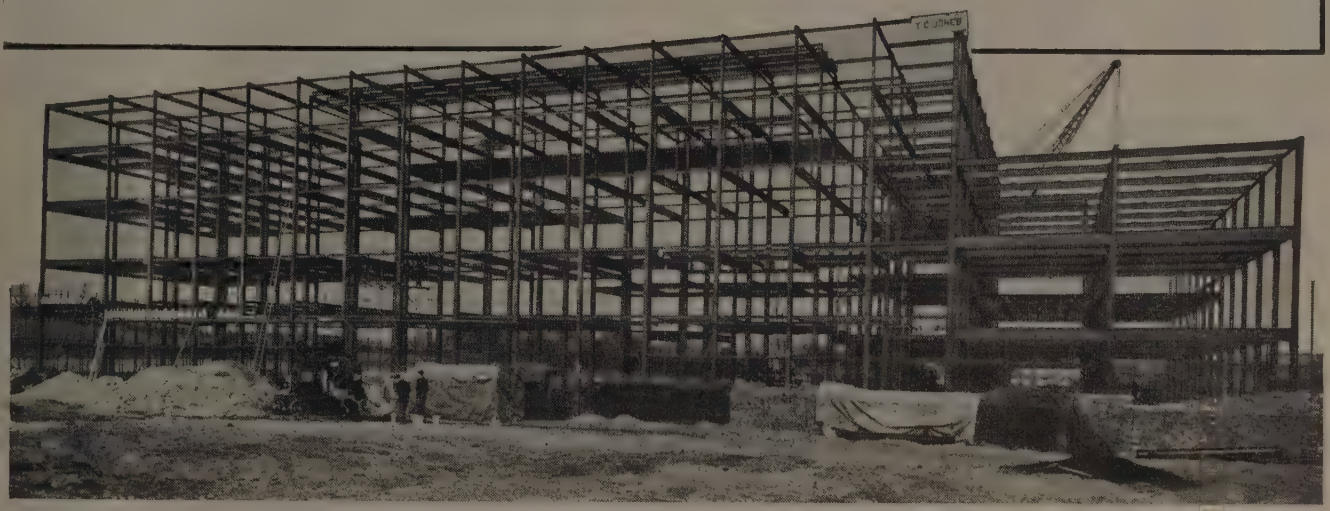
MATERIAL HANDLING DIVISION · BORDESLEY WORKS · BIRMINGHAM · 12 Tel: VICtoria 2371

Also at: London · Manchester · Cardiff · Glasgow · Newcastle-on-Tyne · Bristol · Belfast & Dublin


T. C. JONES
skill, experience and immense resources

STORY of STEEL

In the Service of Industry



Steelwork for the first phase of the New Brewery for South Wales & Monmouthshire United Clubs Brewery Ltd., Pontyclun, Monmouthshire. *Consulting Engineer:* Sidney Culverwell Esq. *General Contractors:* John Morgan (Builders) Ltd.



Steelwork for Raw Materials Handling Plant, installed by Mitchell Engineering Ltd., at the gigantic new Works of the Steel Company of Wales at Margam.



Steelwork for Crane Shop for K & L Steelfounders and Engineers Ltd., Letchworth.

T. C. JONES

AND COMPANY LIMITED

HEAD OFFICE
Wood Lane, London, W.12
Tel: Shepherds Bush 2020

THE 600 GROUP OF COMPANIES

SOUTH WALES OFFICE
Bute Street, Cardiff
Tel: Cardiff 28786

Works: SHEPHERDS BUSH, LONDON. NEASDEN, MIDDX. TREORCHY, GLAM.

JASONS PISTOL

a must-
wherever the problem
is rust











JASONS (EQUIPMENT) LTD., CHERTSEY, SURREY. *Telephone:* **CHERTSEY 2306-7**

JASONS EQUIPMENT (PTY.) LTD., ATLAS ROAD, ELANDSFONTEIN, TVL.
JASONS EQUIPMENT (CANADA) LTD., 205 ST. PAUL ST. W., MONTREAL

S·W·
FARMER
& SON LIMITED

EST. 1898

FABRICATORS IN STEEL

IRON STAIRCASES STEELWORK BALUSTRADING

S.W. FARMER & SON LTD, COURTHILL ROAD, LEWISHAM, LONDON, S.E.13
'PHONE: LEE GREEN 4334-9.



GOOD lighting can only be described as ' good '
When it gives just a little bit more than it should;
When it gives a high order of ease and well-being
And the feeling conducive to the job of seeing.
A high level of light at the working plane
Is most essential to production gain,
But environment, character and the whole field of vision
Are really important to a final decision.
So - employ natural daylight as a means of achieving
A full recognition of " Seeing's Believing."

• •

The prospect before us in economy's drive
Presents many problems from which we derive
Hours of consulting and lots of advice,
Weighty reflections and every device
For saving, economy and conditions improved,
Contented workers and worries removed.
It's the problem of fuel to which we refer,
A National problem we cannot defer,
But here we can offer a sound consolation,
Quick information for your approbation,
For once you've given consideration
To the really BIG savings through Insulation,
You'll go right ahead in the realisation
That you cannot afford a further evasion.

• •

You cannot do better, but you could do worse,
So we'll say it in prose if you don't like the verse : . .

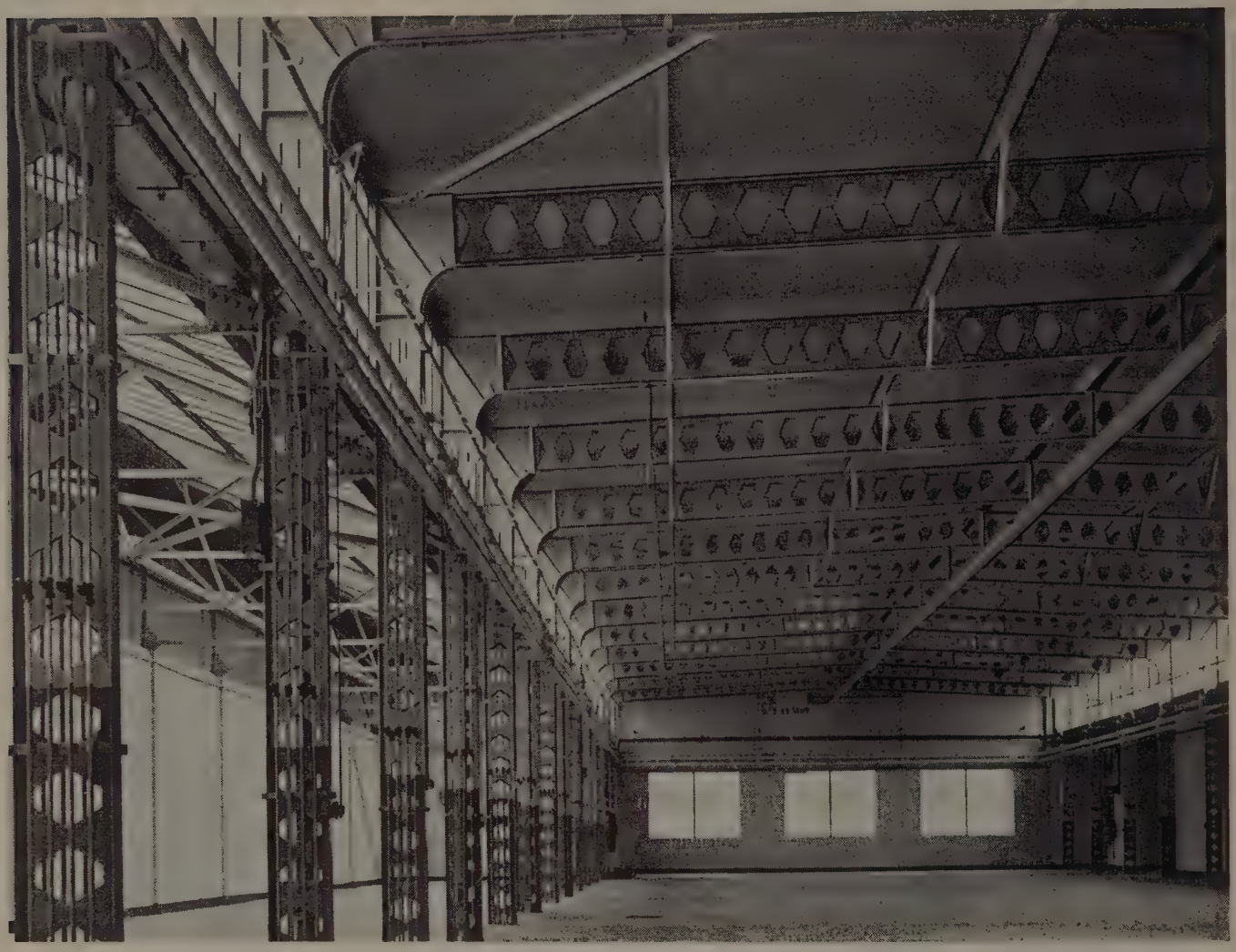
HEYWOODS
OF HUDDERSFIELD

FOR EFFICIENT PATENT ROOF GLAZING AND STRUCTURAL THERMAL INSULATION DOUBLE GLAZING, LANTERN LIGHTS, WALKWAYS ETC., AND ALL ROOFING PROBLEMS

W. H. HEYWOOD & CO. LTD., HUDDERSFIELD. Telephone 6394 (5 lines)

Branches at: London, Manchester, Glasgow, Belfast, Newcastle, Birmingham, Liverpool, Leicester, Nottingham, Bristol.
Associate Company in Eire: W. H. Heywood & Co (Ireland) Ltd., 63-64 Upper O'Connell Street, Dublin.

STEEL ELLIS WORK



New Machine Shop for Messrs. Quasi-Arc Ltd., North-Eastern Trading Estates Ltd., Team Valley . Gateshead

This portal frame building was recently designed, fabricated and erected by us in Castellated Beam Construction. This is the type of construction work in which we are experts, and we should be pleased to offer our experience and service in solving your problems. Castellated Beams are manufactured under licence from Messrs. United Steel Companies Ltd.

JAMES W. ELLIS & CO. LTD.

Head Office: 30-32 GREAT NORTH ROAD, NEWCASTLE UPON TYNE

London Office: 127 Victoria Street, S.W.1.
Sheffield Office: 371 Ecclesall Road, Sheffield, 11.
Derby Office: 17 St. James' Street, Derby.
Leeds Office: 5/7 New York Road, Leeds.

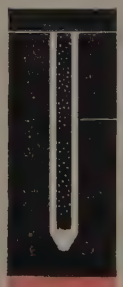
A foundation problem– and the solution



WHEN A PILED FOUNDATION is required, the relative merits of pre-cast or cast-in-situ piles inevitably come under consideration. West's Shell Piling System is a successful combination of both types. A reinforced concrete sectional tube or shell is threaded on to a steel mandrel at the base of which is a solid concrete shoe, the whole of the tube, mandrel and shoe being driven to a predetermined "set" in the load-bearing stratum. The mandrel is then withdrawn and a reinforcement cage is lowered into the tube, the pile being completed by filling the interior with concrete. The method has a number of important advantages. The bearing capacity of each pile can be calculated because the pile is driven to a predetermined dynamic set. Minimum waste occurs as only the last shell driven may have to be cut to take the bearing cap. Skin friction resulting from the driving of the pile is retained since the final set is not disturbed. The concrete core is not fatigued and the pile has a constant cross-section. Shell diameters are 14½ in. 17½ in. and 20 in. for loads up to 40, 60 and 100 tons per pile respectively, depending on length of pile and strata conditions.







Please write for our latest publications

WEST'S SHELL PILING

SYSTEM

WEST'S PILING & CONSTRUCTION COMPANY LIMITED

FOUNDATION SPECIALISTS . DESIGN AND CONSTRUCTION IN REINFORCED CONCRETE

BATH ROAD, HARMONDSWORTH, MIDDLESEX. TEL: WEST DRAYTON 2288

London: Columbia House, Aldwych, W.C.2 *North*: Albion Ironworks, Manchester 10

Midlands: 83 Edmund St, Birmingham 3 *Scotland*: 169 Hamilton Rd, Glasgow E.2

Paris (Seine): Compagnie Générale de Construction de Fours

G4



Terrace of Highworth Houses in Hampshire awarded the Ministry of Housing and Local Government Housing Medal and Diploma, 1954. Designer, Eric Chick; Consulting Architects, Powell & Moya, A/A.R.I.B.A.

CANADIAN TIMBER

builds better houses—quicker, at less cost



Brick and timber faced frame houses sponsored by the Ministry of Works and built by Spooners (Hull) Ltd.



SEND FOR 'TRENDS IN TIMBER CONSTRUCTION'
—an 18-page pictorial study of timber's wide range of uses in present day structures of all types. Write for your free copy to:

COMMERCIAL COUNSELLOR (Timber)
DEPT. Q2, CANADA HOUSE,
TRAFALGAR SQUARE, LONDON S W 1

The architect who makes wide use of Canadian timber in the construction of housing does so with good reason. Timber is warm and hospitable, adds so much to appearance and comfort. It reduces building and maintenance costs to a surprisingly low figure. Wall sections may be prefabricated and wet processes reduced, particularly if timber surfaced to Canadian Lumber Standards is used. Fewer workmen are needed on the site and construction time is cut to the bone. Quite recently, in fact, one Local Authority *proved* that extensive use of timber in terrace houses not only resulted in considerable savings in the cost of materials, but reduced construction time by as much as 23 per cent.

CANADIAN TIMBER **FROM BRITISH COLUMBIA**

Pacific Coast Hemlock. Douglas Fir. Western Red Cedar. Sitka Spruce.

High quality timber produced by members BRITISH COLUMBIA LUMBER MANUFACTURERS ASSOCIATION

Ad No. Q2



BRAITHWAITE PRESSED STEEL TANKS provide a dependable liquid storage system in an unlimited range of capacities suitable for most liquids and viscous substances. Of sectional construction they can be erected at sites where space is restricted and access frequently difficult and can be increased in size when the need arises.

BRAITHWAITE & CO.

ENGINEERS LIMITED

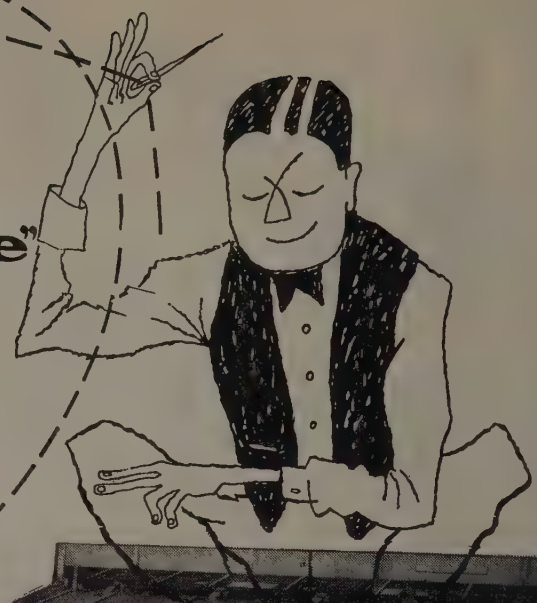
Bridge and Constructional Engineers

LONDON OFFICE: DORLAND HOUSE - REGENT STREET - LONDON SW1 - TELEPHONE: WHITEHALL 3993

"SAFETREAD" FLOORING is

"made to measure"

"Safetread," the strongest and most economical steel flooring for all industrial purposes, is tailor-made for each job. Not merely cut to fit but actually "made to measure," it is no dearer at the start than ordinary steel flooring and, of course, much cheaper in the end.





"Safetread" flooring in use on the Automatic Tube Mill recently installed by Messrs. Head Wrightson Machine Company at the Corby Tube Works of Messrs. Stewarts and Lloyds, Limited.

Write today for full details, to

Allan Kennedy

AND CO. LTD.

MARITIME STREET · STOCKTON-ON-TEES

TELEPHONE: STOCKTON 67706 & 67716 · TELEGRAMS: GRATING STOCKTON-ON-TEES · ALSO AT 207 VICTORIA ST., LONDON, S.W.1



A FLAT-CAMBERED PORTAL ROOF

This illustration shows the steelwork for the roof of a canteen forming the upper storey of a building for Dewrance & Co. Ltd.

Architect:
Reginald W. Lone, F.R.I.B.A.
Consulting Engineers:
Hurst, Peirce & Malcolm, M/M.I.C.E., M/M.I.S.E.
General Contractors:
John Laing & Son Ltd.

Steelwork for the whole building by

DORMAN LONG

DORMAN LONG (*Bridge & Engineering*) LTD. DORMAN LONG (*Steel*) LTD.

All steel fabricated by us is produced in our own works and, when required, is erected in any part of the world.

LIMESTONE CONCRETE



Lockleaze School, Bristol. Photograph reproduced by courtesy of Holland & Hannen and Cubitts Limited.

Construction carried out under the supervision of the City Architect of Bristol, J. Nelson Meredith, F.R.I.B.A.

This modern school in Bristol was built with hard limestone as the concrete aggregate. Such concrete has a low shrinkage factor and possesses high compressive and flexural strengths. It has, moreover, excellent fire resisting properties.

LIMESTONE

FOR CONCRETE

THE LIMESTONE FEDERATION · MANFIELD HOUSE · 376/8 STRAND · W.C.2

TGA 56

Give us the foundations and we will finish the structure — on time



UNITED STEEL STRUCTURAL CO. LTD.

THE UNITED STEEL COMPANIES LTD

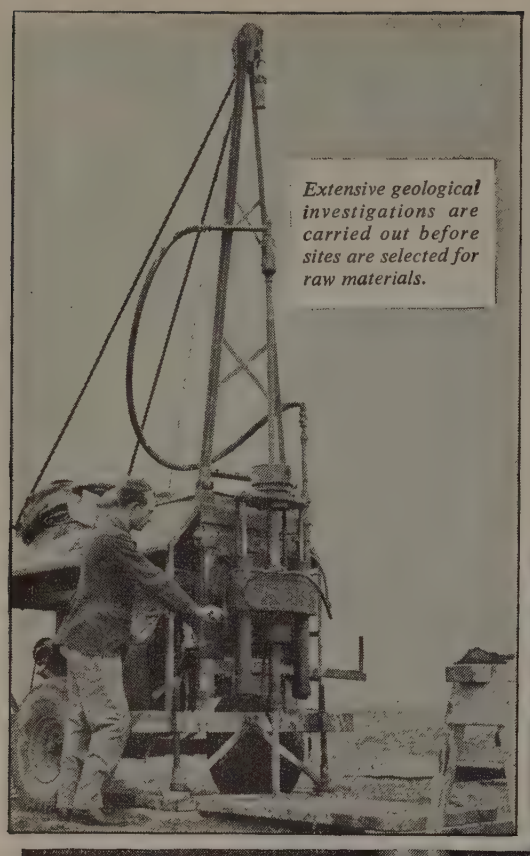
UNITED STEEL STRUCTURAL COMPANY LIMITED

A Subsidiary Company of The United Steel Companies Limited

SCUNTHORPE · LINCOLNSHIRE

London Office: 40, Grosvenor Gardens, London S.W.1.

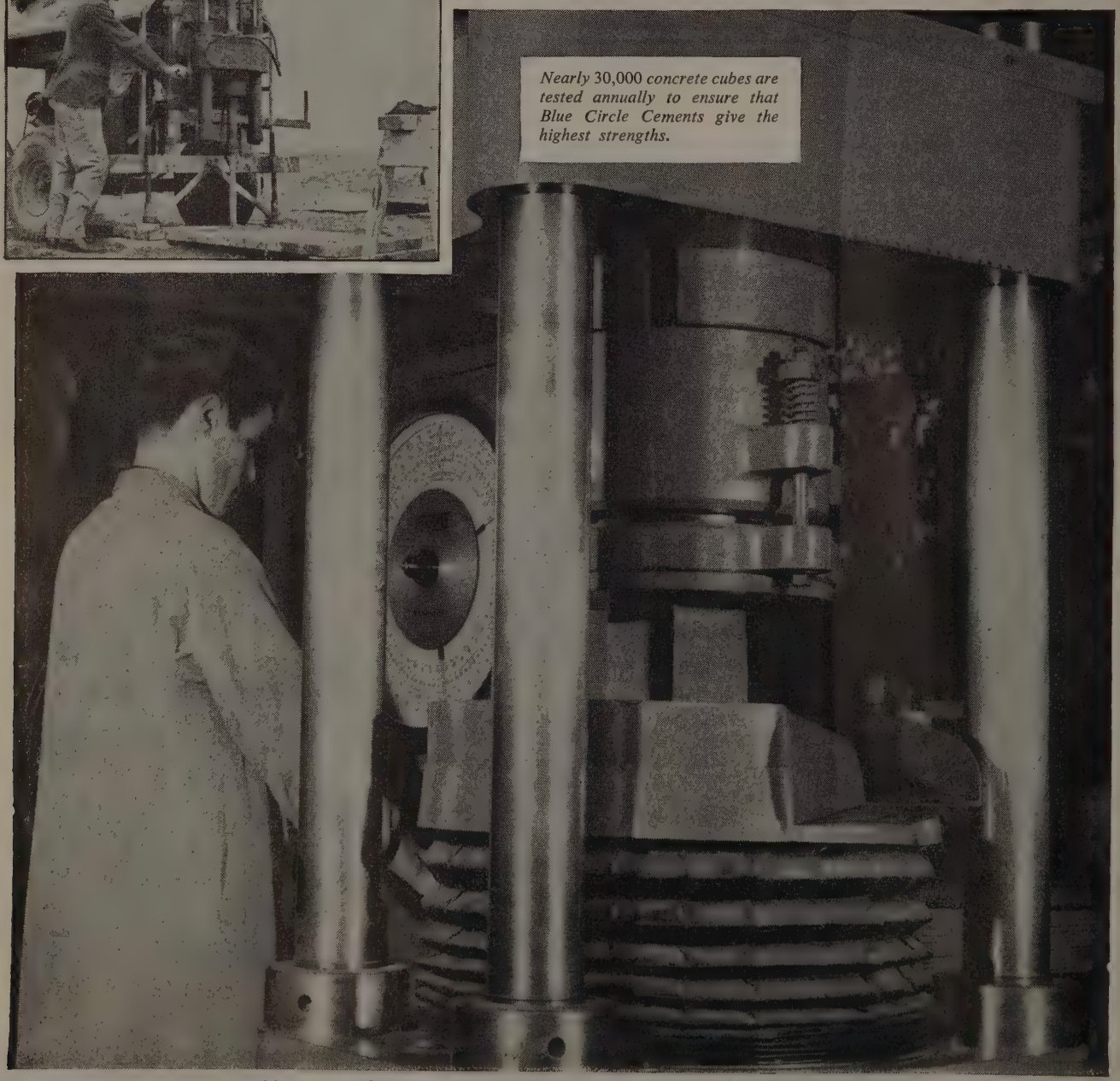
USS 25



Extensive geological investigations are carried out before sites are selected for raw materials.

From start to finish— Research ensures the high quality of all Blue Circle Products

Every year the Blue Circle Group spends over £300,000 on research and development. From the preliminary geological investigations to the testing of the finished product nothing is spared to ensure that the Blue Circle is always the symbol of the highest quality.



Nearly 30,000 *concrete cubes are tested annually to ensure that Blue Circle Cements give the highest strengths.*

This symbol identifies the products of **THE CEMENT MARKETING COMPANY LIMITED**
Selling organization of The Associated Portland Cement Manufacturers Ltd.,
The British Portland Cement Manufacturers Ltd., Alpha Cement Ltd.
Portland House, Tothill Street, London, S.W.1.
Suppliers of Blue Circle Portland Cement, Ferrocrete, '417' Cement, Sulfacrete, Snowcem Cement Paint, etc.
BRITISH CEMENT IS THE CHEAPEST IN THE WORLD

33

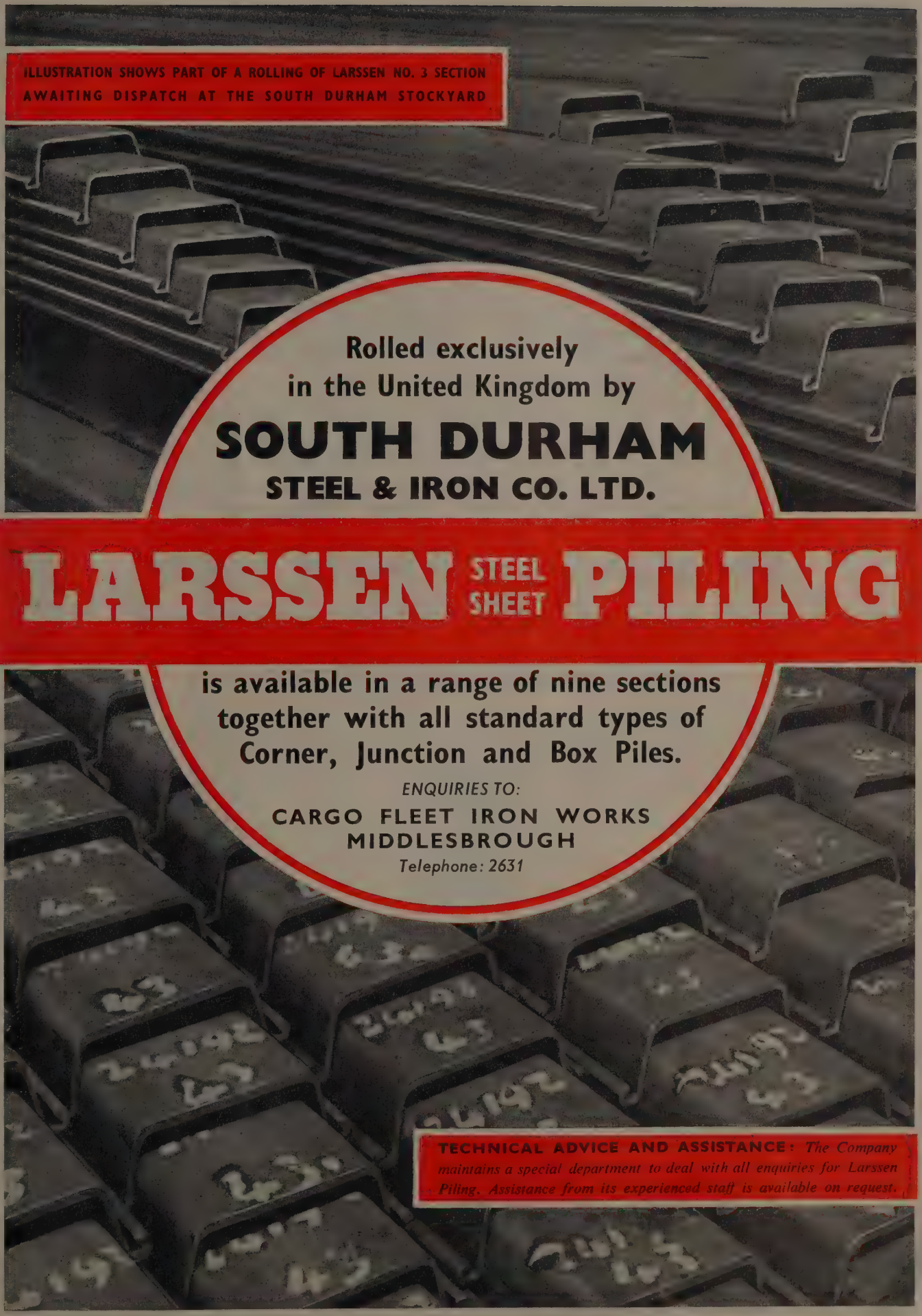


ILLUSTRATION SHOWS PART OF A ROLLING OF LARSSEN NO. 3 SECTION AWAITING DISPATCH AT THE SOUTH DURHAM STOCKYARD

Rolled exclusively
in the United Kingdom by

SOUTH DURHAM
STEEL & IRON CO. LTD.

LARSSEN STEEL SHEET PILING

is available in a range of nine sections together with all standard types of Corner, Junction and Box Piles.

ENQUIRIES TO:

CARGO FLEET IRON WORKS
MIDDLESBROUGH
Telephone: 2631

TECHNICAL ADVICE AND ASSISTANCE: *The Company maintains a special department to deal with all enquiries for Larssen Piling. Assistance from its experienced staff is available on request.*

DAWNAYS
STEELWORK

Specialists in the design, fabrication and erection of riveted and welded steel-framed structures of every description



DAWNAYS LIMITED
BRIDGE & STRUCTURAL ENGINEERS

HEAD OFFICE: **STEELWORKS RD., LONDON, S.W.11** : Telephone **BATTERSEA 2626**

King's Dock Works **SWANSEA 50471**	East Moors Works **CARDIFF 23336**	54 Victoria St., London, S.W.1 **VICTORIA 1541**	Bridge Rd. Works **WELWYN GDN. 3918**	Thorpe Works **NORWICH**
Waterloo Bldgs., London Rd. **SOUTHAMPTON 22474**	40 Park Road **PETERBOROUGH 4547**	Great Field Lane, Marfleet **HULL 32063**	22 High Street **ROMFORD 2106**	7 The Close **NORWICH 23141**

Cables and Telegrams "**DAWNAYS, LONDON**"—Code Bentley's 2nd.

NUCLEAR POWER

LAING

Civil engineering contractors at Britain's first atomic energy establishment, Windscale Works in West Cumberland. (*Two atomic piles, cooling reservoir, blower houses, ancillary buildings and roads and railways in the pile group.*)

LAING

Civil engineering contractors for the construction of uranium plants for gold mining companies in South Africa.

LAING

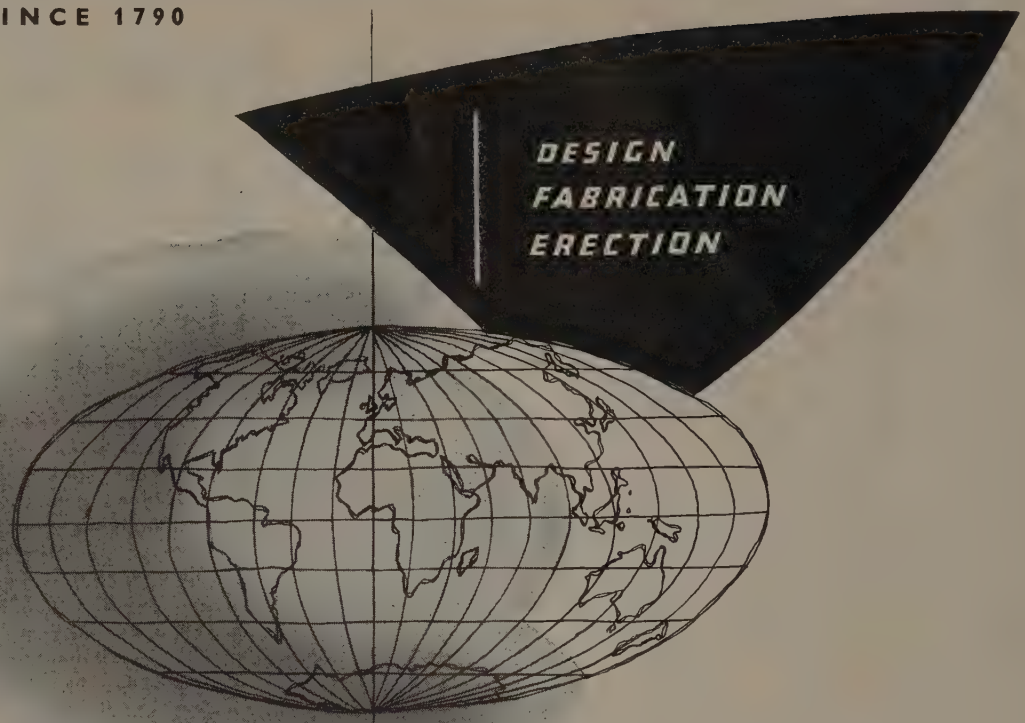
Civil engineering contractors associated with the A.E.I.–John Thompson Nuclear Energy Company Limited for the construction of one of Britain's first nuclear power stations to be constructed primarily for the generation of electricity at Berkeley on the Severn estuary.

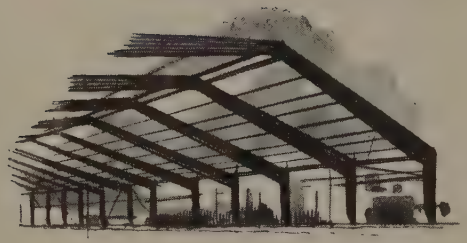
JOHN LAING AND SON LIMITED

Great Britain, Canada, Union of South Africa, Rhodesia

Butterley at home and abroad . . . .

SINCE 1790





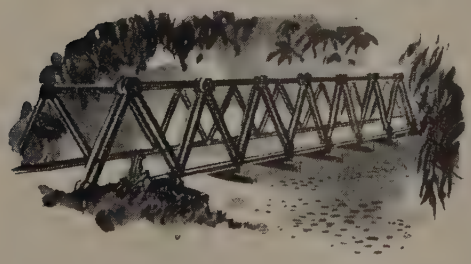
Constructional Steelwork

Examples of Butterley structural steelwork are to be found in all parts of this country and in many countries overseas. In recent years, experiments to perfect methods of welded structure have been highly successful.



Bridge Construction

Railway and road bridges built by Butterley have been supplied to undertakings in Great Britain and many countries abroad. The Butterley Company was one of the pioneers of the "rolling-in" method now universally adopted. To-day, welded methods are widely used, but many bridges are still of riveted construction.



Standard Unit Bridges

Butterley Standard Unit Bridges are in use in many countries providing the ideal solution to speedy bridge construction in places where site preparation is difficult or skilled labour scarce. From five standard units all sizes of bridge can be built.

Also makers of overhead electric travelling cranes, mining and sheet metal machinery, railway wagons and mine cars, Meehanite castings and wrought iron.

THE BUTTERLEY COMPANY LIMITED · RIPLEY · DERBY · ENGLAND Tel.: Ripley 411 (9 lines)

London Office: 9 UPPER BELGRAVE STREET, S.W.1. Tel.: SLOane 8172/3

G3

The cement which is

COMPLETELY IMMUNE

from the effects of

SULPHATES

IN ANY CONCENTRATION

CIMENT FONDU

Regd Trade Mark

ALUMINOUS CEMENT

* Concrete made with Aluminous cement is not merely resistant to attack when used in soils containing a relatively low concentration of Sulphates. It remains immune from chemical attack by Sulphates in *any* concentration.

* Concrete made with Aluminous cement is equally impervious to these conditions when in an immature state. From first to last it remains unaffected by Sulphates.

* Concrete made with Aluminous cement provides an additional margin of safety! It is also resistant to attack by dilute acids often prevalent in sulphate-bearing clays, made-up ground and industrial effluents.

* Aluminous cement also provides concrete of unequalled high early-strength.

CIMENT FONDU is manufactured by

LAFARGE ALUMINOUS CEMENT COMPANY LIMITED

73 Brook Street, London, W.1 Telephone: Mayfair 8546

AP3-1289


COAL BUNKER
CHESTERFIELD
CLIENTS: WOODALL-DUCKHAM
CONSTRUCTION COMPANY LIMITED
PETER LIND & CO LTD
ROMNEY HOUSE, TUFTON STREET LONDON SW1
TELEPHONE ABBEY 7351

VOL. XXXV. No. 2. FEBRUARY, 1957

THE STRUCTURAL ENGINEER

THE JOURNAL OF THE INSTITUTION OF STRUCTURAL ENGINEERS

Founded 1908. *Incorporated by Royal Charter,* 1934

11 UPPER BELGRAVE STREET, LONDON, S.W.1. Sloane 7128/9.

President:
J. GUTHRIE BROWN, M.I.Struct.E., M.I.C.E.

Secretary of the Institution:
Major R. F. Maitland, O.B.E., M.I.Struct.E., M.Soc.C.E. (France).

Assistant Secretary:
Herbert R. H. Gray, A.C.I.S.

CONTENTS

PAGE

POST-WAR DEVELOPMENTS IN GERMAN STEEL BRIDGES AND STRUCTURES 53
By G. Bernard Godfrey, A.M.I.Struct.E., A.M.I.C.E.
The Structural Engineer, February, 1957

FACTORY IN CONCRETE FOR THE PRESSED STEEL CO. LTD., STRATTON ST. MARGARET 69
By D. H. New, E.R.D., B.Sc.(Eng.), M.I.Struct.E., M.I.C.E., and R. Sanders, M.I.Struct.E.
The Structural Engineer, February, 1957

THE USE OF GUNITE AS A STRUCTURAL MATERIAL 81
Discussion on the paper by Mr. T. Whitley Moran, B.A., B.A.I., M.I.Struct.E., M.I.C.E.
The Structural Engineer, February, 1957

CORRESPONDENCE 86

BOOK REVIEWS 80

INSTITUTION NOTICES AND PROCEEDINGS 87

All Editorial communications should be addressed to The Editor, The Structural Engineer, 11, Upper Belgrave Street, S.W.1. All MSS. should be typewritten and algebraic signs and formulæ be indicated distinctly.

The Institution of Structural Engineers, whilst being at all times desirous of receiving communications from members and others, does not accept any responsibility for the opinions expressed by any individual Authors or Speakers.

Annual Subscription Rate to the Journal 54s. 0d. post free

Printed and Published for the Institution by JOHN MORRIS PUBLICITY LTD., Publicity House, 41 Streatham Hill, London, S.W.2, to whom all communications regarding advertisements should be addressed.

Modular Steelwork

for

The Bowater Paper Corporation Ltd.

Architects :

FARMER AND DARK.
Chartered Architects.

Main Contractors :

HOLLAND & HANNEN AND CUBITT Ltd.

Steelwork :

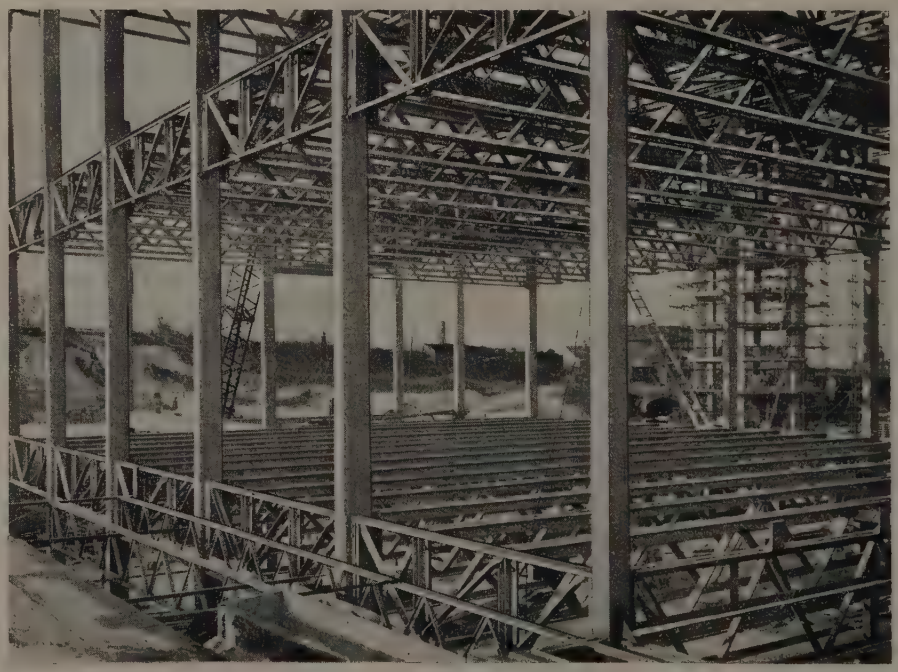
By SOMMERFELDS Ltd.



A general view of some of the buildings under construction. In the far background is the Drawing Office with a roof of triangulated space frame units giving a clear floor area 120′ x 67′ span.

Part of the expansion programme of The Bowater Paper Corporation Limited at Northfleet included extensive Office premises. The Architects designed these on a 3′ 4″ "Modular" grid employing a Lattice steel structure. The grid allows complete flexibility of internal partitioning and the lattice beams allow all services to be run between floor and ceiling.

Steelwork for other modular buildings at present under construction by Sommerfelds include Laboratories and Offices for I.C.I at Welwyn, and another set of Office buildings for The Bowater Paper Corporation Limited at Merseyside.



Part of the 4-storey Block in course of erection. The close spacing of the 40′ beams considerably reduces overall flooring costs.

Sommerfelds LTD. | LONDON OFFICE: 167 VICTORIA ST. S.W.1 TEL: VIC. 1000
WELLINGTON · SHROPSHIRE TEL. 1000

Post-War Developments in German Steel Bridges and Structures*

By G. Bernard Godfrey, A.M.I.Struct.E., A.M.I.C.E.

" Stille stehen ist rückwärts gehen "

" A Report on Structural Engineering in Germany "[1]† presented to the Institution in 1946 by Mr. John Mason, Member of Council, embraced many aspects of war-time developments associated with our profession. It is the object of the present paper to give an impression of the trends and achievements in the development of steel bridges and structures since that time.

Although sources of information relating to design are listed in the bibliography, this paper deals largely with the constructional details of the structures described.

As some of the illustrations are in metric units, it may be of assistance if some elementary conversion figures are quoted for easy reference :

1 metre = 3.28 ft. = 39.37 in.
1 mm. = 0.04 in. 1 kg. = 2.2 lb.
1 kg/sq. mm. = 0.635 ton/sq. in.

Steels

British structural steels are described by quoting the relevant British Standards, Continental steels by reference to their minimum U.T.S. in kg/mm.[2] For example, the most common mild steel in Germany is St.37 (Stahl 37), often quoted as being the equivalent of our B.S.15, although the minimum U.T.S. is only 24 tons/sq. in., compared with our 28 tons/sq. in. However, the minimum yield stress is claimed to be 24 kg/mm.[2] (15.25 tons/sq. in.) as in B.S.15.

A high-tensile steel, St.52, which was produced before the war, is still widely used, but special steels with high yield points (m.e.S.) have been introduced, particular attention being paid to welding qualities.

Rheinische Röhrenwerke produce the HSB series (Hochfeste Schweissunempfindliche Baustähle) the chemical and mechanical properties of which are given in Table 1.

Electrodes have been developed to suit the individual steels, e.g. electrodes with a Cu-Ni-Mo steel core are used with HSB 55.

HSB steels have been used for the Duisburg-Homberg, Düsseldorf-Neuss and Porta bridges, described later, and for spherical gas-holders, pipelines and tubular structures.

Mannesmann have developed FB 50 (Feinkorn Baustahl 50) the chemical and mechanical properties of which are given in Table 2. This steel has been used in the same circumstances, and often the same structures, as HSB 50.

The steels used in bars or wire for prestressing concrete vary from St.90 to St.165, according to the diameter and system employed.

† Numbers in parenthesis refer to the bibliography.

* *Paper to be read before the Institution of Structural Engineers, at 11, Upper Belgrave Street, London, S.W.1, on Thursday, 14th February, 1957, at 6 p.m.*

Recently, some Continental Bessemer converters have been using an oxygen-enriched blast. It is claimed that the resulting steels have the same properties as the open-hearth variety.

Standards

Appendix I gives a list of the main German Standards applicable to steel bridges and structures. A few quotations from these Standards occur, where appropriate, in the text, but readers will, no doubt, be interested in some typical permissible stresses for mild steel, as shown in Table 3.

BRIDGES

General

In 1954, at the official opening of the new Sulzbachtal bridge, described later, Dr. Seebohm, the Federal Minister of Transport, stated that nearly 200 miles of highway bridges had been reconstructed since the war, a length longer than that built during the whole of the nineteenth century.

Further evidence of the destruction wrought in Germany and of the measures taken to reinstate or repair railway bridges is given by Fig. 1.

The Development of Bridge Design

It will be appreciated that numerous temporary structures, such as Bailey bridges, were provided by the occupying forces in 1945. Nevertheless, the free movement of all types of transport depended on the reconstruction of such major works as Rhine bridges or autobahn viaducts. Many of the structures were built for the first time during the Hitler regime, some even during the war. As they were built when priority was given to armaments, it is reasonable to assume that the minimum amount of steel was employed consistent with advanced design as it was then known. Some of these designs, however, which were then universally acclaimed, now look heavy or even clumsy compared with the structures of today, although the latter are often designed for greater loads.

The design of superstructures underwent a change midway between the two World Wars when stringers and cross-beams were rigidly connected at the same level as the main girders to form a grid system (*Trägerrost*) which supported the concrete slab. Then stiffened curved steel plates (*Tonnenbleche* or *Buckelbleche*) were introduced, providing an alternative to concrete slabs. Subsequently, Schaper[2] evolved prefabricated units in which a flat steel plate was rigidly connected to a supporting grid.

It will be observed that even prior to the war, there was a tendency to design a number of members to act as a single unit. Since the war, whole superstructures have been designed in this way. At the same time, advantage has been taken of the great progress made in concrete technology.

Type	Chemical Analysis			U.T.S. in tons/sq. in.	Yield in tons/sq. in.				Elongation %	Notch Test @ O°C. ft. lb./sq. cm.
	C %	Si %	Mn %		16 mm.	30 mm.	50 mm.	70 mm.		
HSB 40	0.18	0.25	0.60	25.4—31.7	18.4	17.8	17.1	16.5	28—24	64
HSB 45	0.18	0.35	0.80	28.6—34.9	20.3	19.7	19.0	18.4	26—22	57
HSB 50	0.20	0.45	1.10	31.7—38.1	22.9	22.2	21.6	21.0	24—20	50
HSB 51	0.20	0.45	1.10	32.4—39.4	24.8	24.1	22.9	21.6	22—18	50
HSB 55	0.20 Cu 1.10	0.45 Ni 1.00	0.90 Mo 0.20	34.9—43.2	29.2	28.6	28.0	27.3	22—18	57

Table 1. Properties of HSB Steels

Chemical Analysis					U.T.S. in tons/sq. in.	Yield in tons/sq. in.			Elongation %	Notch Test @ O°C. ft. lb./sq. cm.
C %	Si %	Mn %	P %	S %		30 mm.	30—50 mm.	50—80 mm.		
max. 0.20	0.40—0.55	0.90—1.30	max. 0.05	max. 0.05	31.7—38.1	22.9	22.2	21.6	24—20	50

Table 2. Properties of FB 50

Type of Stress	Basic loading tons/sq. in.	All loads, including wind etc. tons/sq. in.
Bending and Tension	10.16	11.43
Shear	5.84	6.60
Equivalent (Huber-von Mieses-Hencky)	11.43	12.19
During erection	13.08	—
Stability (compression)	8.89	10.16

Table 3.
DV 804, Railway Bridges, and DIN 1050, Structures

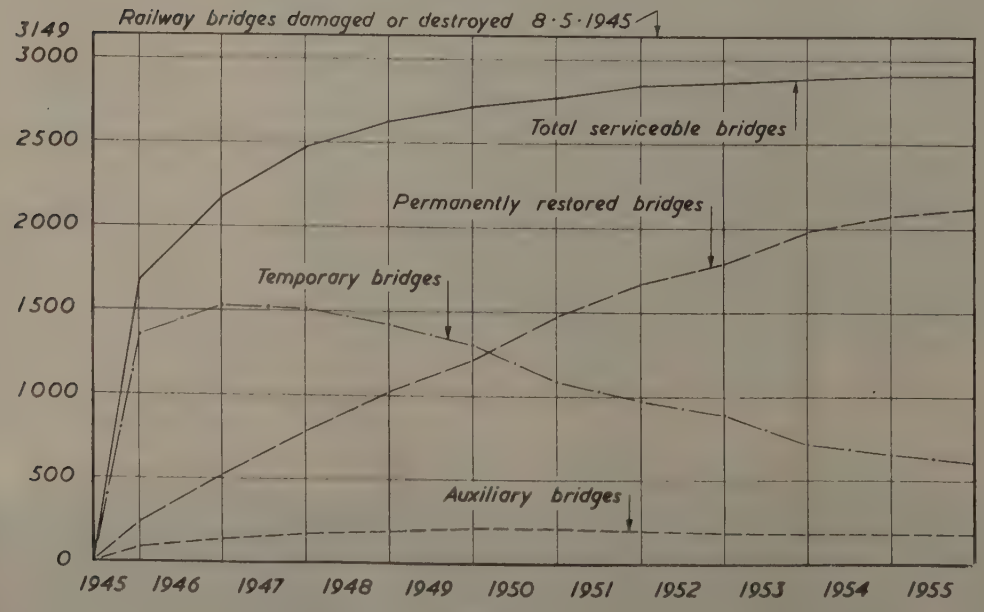


Fig. 1

Despite the fact that changes are taking place in many spheres, two main developments dominate modern bridge design in Germany, viz :

(1) Steel decks associated with cellular or other torsionally stiff construction.
(2) Composite construction.

While notable exceptions can be quoted, steel decks are normally used for large spans, where a saving in dead load is of great importance, and composite construction for medium or small spans.

Some descriptions of modern German bridges have already been given by Chettoe[3]. In the following pages it is the intention to describe not only those bridges which follow common present-day practice, but also some of the more novel and, perhaps, less practical solutions.

Special techniques have evolved for the fabrication, transportation and erection of modern German bridges. When the war ended it became necessary to build very large heavy floating cranes to clear the wrecks from the main waterways. Subsequently, when these cranes became available for bridge reconstruction, it was possible to fabricate the bridges in the largest components which could be transported by autobahn, canal or river, thus reducing site connections to a minimum.

When comparisons are made with former structures, startling economies in steel consumption are revealed. These economies have often been made through an increase in the amount of fabrication and welding, with the result that the overall saving in cost is much smaller.

The burden falling on drawing offices is heavy. Prewar, there was a designer or draughtsman for every nine or ten fabricators or erectors. The ratio is now one to four or five.

For all big bridges, competitions are held. The appropriate authorities give an outline design, but the contractors tendering may modify the design or submit entirely new schemes. A considerable amount of time must be wasted by the unsuccessful competitors, but the end seems to justify the means.

When a design has been agreed, the work is given to a consortium of fabricators. This not only ensures speedy completion, but provides continuity of employment for firms possessing expensive plant.

Steel Decks

A number of steel decking systems have been patented, but the possible variations in design are almost limitless. In essence, for highway bridges, the deck consists of a continuous steel plate supported, at about 4 to 8 ft. centres, by the cross-girders and stiffened, at about 12 in. centres, by stringers composed of steel flats, bulb flats, angles or inverted tees or by plates pressed into a U or trapezoidal shape. The stringers are made as long as possible and usually pass through the cross-beams.

Although the plates are continuous over stringers and cross-girders respectively, their elastic behaviour varies owing to the differing stiffness of these supports. For this reason, the plates are described as orthogonal anistropic plates (or just orthotropic plates).

The plate serves three purposes, viz :

1. As the top flange of the main girders.
2. As the flange of the T-section composed of plate and stiffener.
3. As a load-carrying element between the stiffeners.

In consequence, some rather complicated equivalent stresses can arise. A number of methods of design[4–7] are in use, all of which achieve much the same result. Tests have been carried out on models, full-size deck units and completed structures[7–10] the variations between theory and practice usually being remarkably small.

When asphalt carpets were first employed, designers were disturbed lest the asphalt should strip from the flat surface of the plates and various welded connectors were adopted to prevent this happening. Experience has shown that such mechanical methods are unnecessary. Nowadays, for example, the plate is thoroughly cleaned and a layer of hard mastic asphalt applied. Then an insulating layer, e.g., aluminium foil, is laid, followed by further carpets, the whole addition to the plate not exceeding 2½ in. in thickness.

It is now common to use steel accessories with steel decks. Many of the kerbs in the bridges described are made from rolled sections or bent plates. In addition, tramrail supports are welded or bolted directly to the deck, a practice now spreading to railway bridges, even though the rails often rest directly on a layer of rubber which has a cushioning effect.

Bridges Incorporating Steel Decks

Girder Bridges

Among the most beautiful bridges developed by the Germans are those with continuous girders having very low depth/span ratios. The German firm M.A.N. (Maschinenfabrik Augsburg-Nürnberg A.G.) has been largely responsible for the bridge recently built over the River Sava in Belgrade, with spans of 245 + 855 + 245 ft., the central span being the largest of this type in the world.

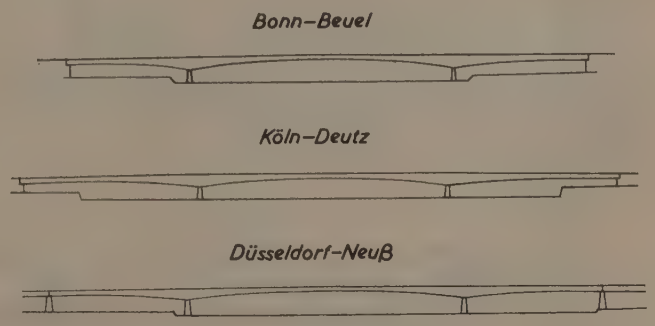


Fig. 2

While many spans of from 200 to 400 ft. have now been built in Germany, it is useful to examine the three larger bridges shown in Fig. 2 which were built over the Rhine when the new system of construction was evolving.

Lange[11] quotes the details given in Table 4.

As the Germans have been very preoccupied since the war with the buckling and torsional stability of such slender sections, it is interesting to consider how these problems are overcome in the bridges mentioned.

In the Bonn-Beuel bridge (built 1948/9), *Tonnenbleche* form the top flange of four main girders which are heavily braced. In the Köln-Deutz bridge, (built 1947/8) a triple-cell box girder is employed, with stiffened plates for both top and bottom flanges. When this bridge was designed, the modern asphalt carpet had not evolved. Instead, a reinforced con-

Bridge	Bonn-Beuel (*Tonnenbleche*)	Köln Deutz (Flat deck + concrete)	Düsseldorf Neuss (Flat deck + asphalt)
Largest span in ft.	643	605	675
Depth/span ratio at mid-span	1/65	1/56	1/62.5
Depth/span ratio at a pier	1/18.6	1/23.6	1/26.5
Weight in lb. per sq. ft. of bridge	132	12)	104

Table 4.

crete slab, 4.8 in. thick, is laid over the steel deck. The Düsseldorf-Neuss bridge (built 1950-1) consists of two box-girders rigidly coupled by three bracings in the central span and two in the outer spans. The asphalt carpet was prevented from slipping by zig-zag ribs welded to the steel decks.

Both Stüssi[12] and Massonnet[13] give a method of treating torsion in cellular sections, such as in the Köln-Deutz bridge. A method of calculating the bracing between box sections, as in the Düsseldorf-Neuss bridge, is given by Daniel and Warolus[14].

The Werratal Autobahn Bridge[15 16]

The prewar bridge comprised four trusses, 26 ft. deep, continuous over spans of 262 + 315 + 315 + 262 + 210 ft., the total length being 1,364 ft., supported by sandstone piers, the maximum height of which was 170 ft. This bridge was totally destroyed by blowing up two of the piers, the wreckage blocking a road, a railway and the Werra.

Despite the fact that this was a vital link in the *N-S* autobahn axis, permanent replacement could not commence until 1950 when 11,500 cub. yd. of concrete and 6,250 sq. yd. of stone facing were required to replace the piers.

At that time steel was so scarce that the two separate superstructures which comprise such autobahn bridges could not be built simultaneously. In April, 1951, M.A.N. commenced the downstream structure in composite construction, as shown in Fig. 11, and in the summer of 1952, Stahlbau Rheinhausen built the upstream structure with a steel deck, as shown in Fig. 3.

With the exception of the bulb flats, which were in St. 52, the steelwork was constructed in St.37, the total weight being 1,555 tons.

To allow for the 1.5 per cent cross-fall of the deck, the main girders were made 19.45 ft. and 19.13 ft. deep respectively. The webs are 0.4 in. thick, necessitating vertical stiffeners at 6 ft. 6 in. centres on the inside face and a number of horizontal stiffeners, as shown in Fig. 3.

The girders were delivered in 52 ft. lengths and in half-depths which were riveted together on the site and erected with the cantilever deck projections attached. The girders are braced at intervals of 26 ft. as shown in Fig. 3.

The steel deck is 0.48 in. thick and is supported by cross-girders 22 in. deep, at 6 ft. 6 in. centres, and $6\frac{1}{2}$ in. × 5/16 in. bulb flat stringers, at 10 in. centres. Sections 13 ft. long and 21 ft. 4 in. wide were riveted to the main girders, but welded to one another.

The surface of the steel deck was sand blasted and painted with bitumen, after which a layer of aluminium foil and two carpets of mastic asphalt were laid. At intervals of 26 ft. very light steel angles were fixed to the deck transverse to the bridge axis to prevent movement of the asphalt.

The superstructure was tested on completion with a 240 ton " train." The maximum deflection in one span was 2.16 in., compared with a deflection of 1.2 in. at a corresponding point in the adjacent composite superstructure.

Although the approaches slope down to the bridge, the old superstructures were almost horizontal. The new superstructures have a pronounced vertical curve, as shown in Figs. 4 and 12.

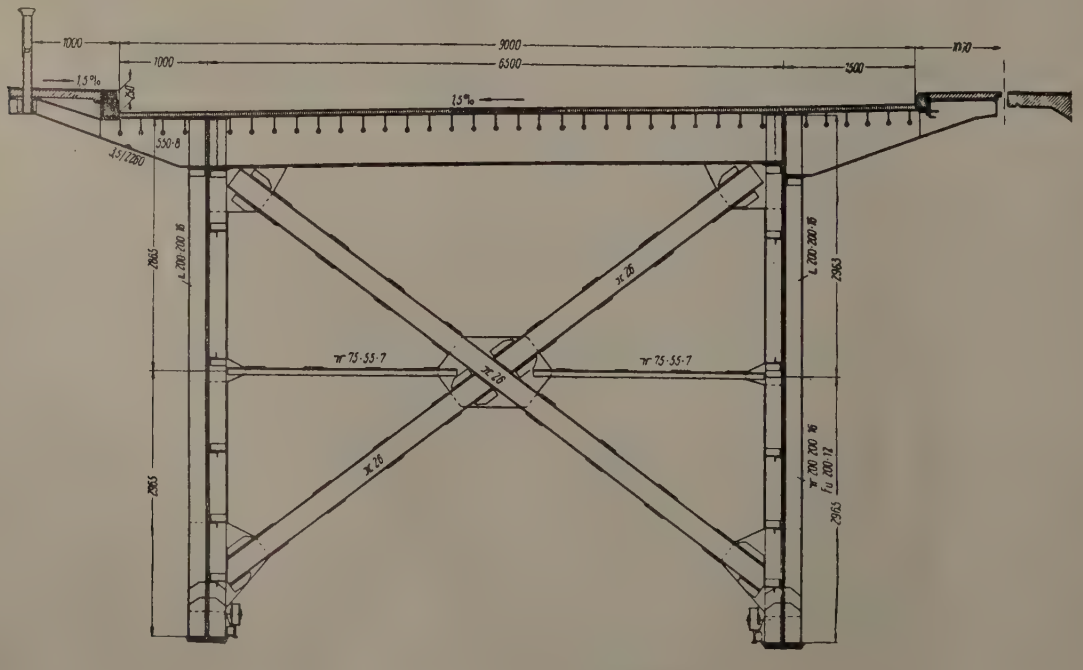


Fig. 3.—Werratal Bridge



Fig. 4.—Werratal Bridge

The Weser Bridge, Porta[17]

The bridge shown in section in Fig. 5, which was completed in 1954, is one of the best examples of a superstructure designed as a single integral unit.

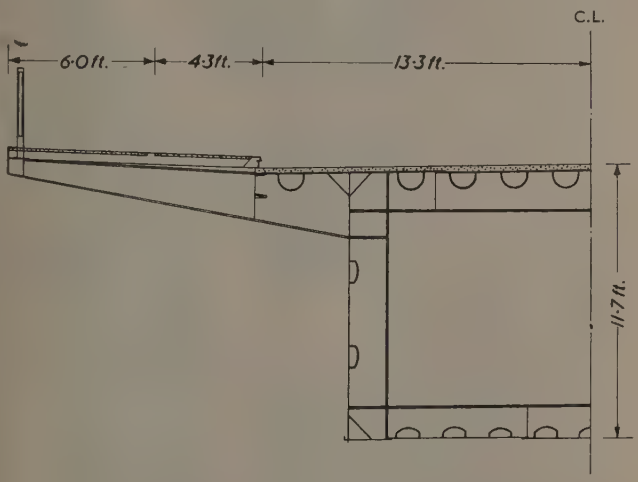


Fig. 5.—Weser Bridge, Porta

Although continuous over unsymmetrical spans of 209 + 255 + 348 ft., the box girder has a constant depth of 11.5 ft., variations in moment and shear being matched by variations in quality of steel (70 per cent HSB 50, 30 per cent St.37) and plate thickness. The whole of the deck is in HSB 50, the plate thickness varying from 0.5 in. in the smaller spans to 0.8 in. in the main river span.

The U-shaped stiffeners and the diagonal plates at the junction of the webs and flanges are characteristic of Professor Dörnen. The deck stiffeners are made from plates 32 in. or 24 in. wide by 0.24 in. thick. The other stiffeners are not as deep. In his paper[17] Dörnen compares the properties of U stiffeners and bulb flats. It will be observed that the length of fillet weld required for hollow stiffeners is half that required for any of the stiffeners with single stalks.

The webs of the box-girder were butt-welded longitudinally and transversely. The deck and floor are butt-welded transversely but lapped longitudinally.

Dörnen made the following comments on the steelwork.

> Complete liberty in design was given by using only plates, i.e. avoiding rolled sections or rods. Consequently, the correct thickness of material could be supplied at any point, resulting in a reduction of tonnage of 15—20 per cent. The costs entailed by extra fabrication and welding reduced the final economy to 5—6 per cent. In such cases, the weight of weld metal may be up to $2\frac{1}{2}$ per cent of that of the structure, against 1 per cent for more usual structures. By using a box-section with no rivet heads, no cover-plates and no re-entrant angles, the surface to be painted was reduced to almost the minimum possible. The prevention of rust starts on the drawing board !

The steelwork in the superstructure, excluding bearings, kerbing and railings, weighed 884 tons or 53 lb. per sq. ft. on plan.

Johannes Dörnen and C. H. Jucho supplied the steelwork.

Railway Bridges

Steel decks have now been employed for a large number of small single-span railway bridges, where they are particularly useful when headroom is restricted.

Fig. 6 shows one of a pair of similar welded box girders, each supporting one track, erected between Cologne and Aachen. The span is 118 ft. and the weight 85 tons.

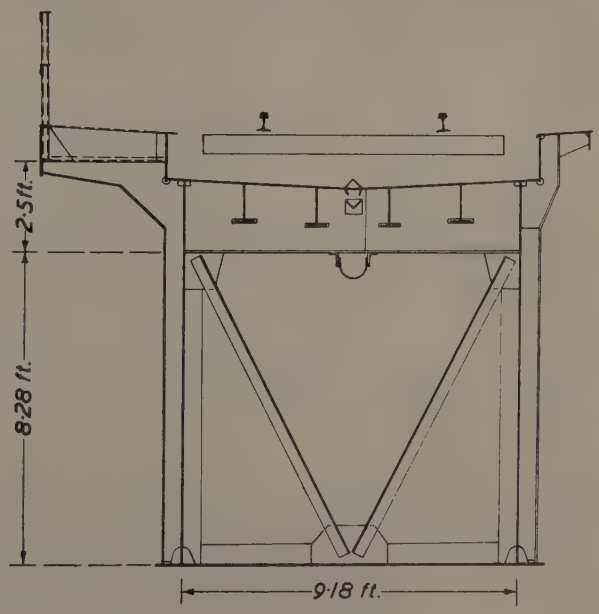


Fig. 6

Suspension and Bridle-Chord Bridges

The Köln-Mülheim Bridge[8 18]

As the Author has arranged to show a film of the bridge, only brief particulars are recorded here.

The spans are 279 + 1033 + 279 ft., as shown in Fig. 7, with a length of flood bridge (which is in composite construction). The superstructure is composed of two plate girders, 10.82 ft. deep, between which are a carriageway and two tram tracks, together with cantilevered footpaths and cycle tracks.



Fig. 7.—Köln-Mülheim Bridge

The deck consists of a steel plate, 0.48 in. thick, with bulb flat stringers, 7.2 in. × 5/16 in., at 12 in. centres and cross-girders at 6 ft. centres, the construction resembling that in Fig. 3.

In Table 5 a comparison is made between the tonnages for the new bridge and the former suspension bridge, completed in 1929, which was designed for a smaller load.

	1929 bridge	1951 bridge
Pylon frames girders decking parapets	10,415	4,454
Suspension cables	1,582	942
Other steel	893	414
Total	12,890	5,810

Table 5.

57 per cent of the 4,454 tons in the new superstructure was in St.52 and 66 per cent was welded.

485,000 ft. of weld were laid in the shops and 41,000 ft. on the site.

Much of the preliminary research work on the steel decking was undertaken by M.A.N. Many firms took part in the actual reconstruction.

The Duisburg-Homberg Bridge[7 19 20]

The bridge shown in Fig. 8, which was completed in 1954, is a bridle-chord bridge designed by Demag and erected by a consortium consisting of Demag, Stahlbau Rheinhausen, Krupp and G. H. H. (Gutehoffnungshütte).

There are three main spans of 421 + 935 + 421 ft., with a short flood bridge, and the pylons are 108 ft. high.

The cross-section comprises two box girders, 13 ft. deep, with cross-beams at about 7 ft. centres, carrying a deck, and cantilevers supporting footpaths and cycle tracks.



Fig. 8.—Duisberg-Homberg Bridge

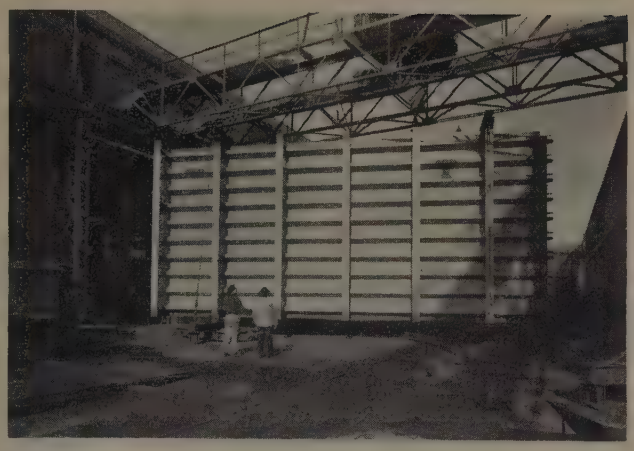


Fig. 9

The deck, which consists of a steel plate, 0.56 in. thick, reinforced by trapezoidal stiffeners, was constructed in large units, as shown in Fig. 9. The design was developed by Demag in conjunction with Dr. Sievers, who also made a study of the box stiffening girders,[21] a short length of which is shown in Fig. 10.

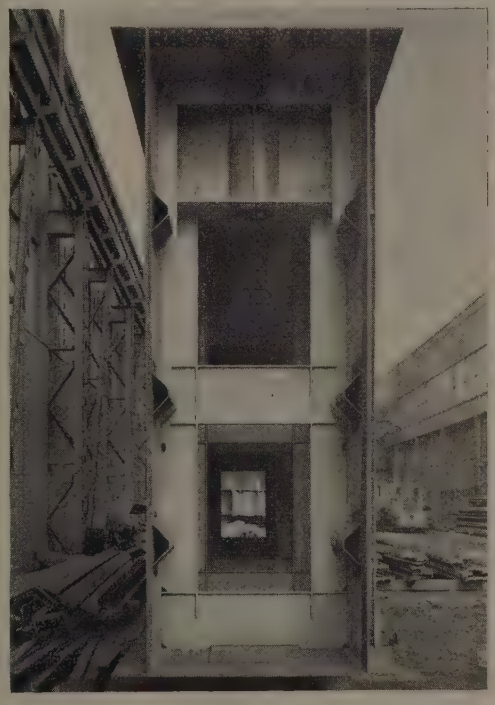


Fig. 10

The side spans were erected on temporary supports and the central span cantilevered out from both piers, during which operation temporary diagonal cables were used.

Composite Construction[22—25]

Bridges and structures in composite construction, where steel girders provided with shear connectors form an integral unit with the reinforced concrete slabs which they support, have been used intermittently abroad for a quarter of a century.

As a result of research in laboratories and on actual practical examples in Germany, Switzerland and elsewhere, the German Commission for Steel Structures were able to issue "Provisional Regulations for the Design of Girders in Composite Construction" in July, 1950. In 1954, however, these were replaced by a Standard, DIN 1078, published in two parts, the first containing the actual regulations and the second an explanatory memorandum.

Although lengthy, even this Standard has to be read in conjunction with others, principally DIN 4227—Prestressed Concrete.

A complete translation of DIN 1078 has been deposited in the Library of the Institution. Some of the more important provisions are mentioned here to give a background for the examples to be described.

The Application of DIN 1078

Modular Ratio

German concrete is expressed in terms of its crushing strength in kg/sq.cm. at 28 days. Table 2 of DIN 1078 quotes modular ratios m between 7.0 and 5.3 for concretes B.300 to B.600 (4267 to 8534 lb./sq. in.).

Creep and Shrinkage[26—28]

Allowance for creep and shrinkage may be made in a number of ways, some being approximations, some so-called 'exact' methods.

A common method for creep, suggested by Froelich,[26] is to increase m according to the formula $m^1 = m\ (1 + \varphi)$, values of φ up to 2 being adopted. Some of the resulting augmented values for the modular ratio may seem high, but a figure of 30 has been used in the U.S.A.

The augmented value m^1 is then used for all calculations for permanent loads.

The Regulations issued in 1950 stated that it was not necessary to calculate the effect of shrinkage and creep for simple spans under 100 ft. or for continuous spans under 24 ft. This proviso seems to have disappeared for DIN 1078.

Effective Breadth of Slab

DIN 1078 gives an approximate method for calculating the effective breadth of the slab, but Rüsch[29] and others have described more exact methods.

Thickness of Concrete Slab

Minimum thicknesses of slab are quoted for various live loads and concrete qualities, e.g. the thickness for a 60 ton load and B.450 or B.600 concrete must be at least 7.2 in.

B.450 or B.600 concrete must be used where no asphalt carpet is employed, i.e. where the concrete carries the traffic directly. In addition, the cover over the top reinforcement must be increased by 0.4 in., the extra thickness being ignored in all stress calculations.

Despite these precautions, most engineers favour the use of transverse prestressing to provide a completely crack-free surface.

Shear Connectors[30]

Shear connectors may take many forms, some generally accepted types being given in DIN 1078. From examination of a number of schemes, however, it appears that the most popular is the stirrup type, as shown in Fig. 13.

Composite Effect

Unless during construction, it is possible to prop girders at intermediate points in the span, composite

effect applies largely for live load only, the dead load, excluding asphalt surfacings, parapets etc., being supported by the steelwork only.

Prestressing

If, with continuous construction, appropriate measures were not taken, heavy tensile forces would occur in the concrete slabs in the regions of negative moment near supports. Two methods are adopted, which are usually applied together, but which may be used separately.

The first method comprises raising the steel girders by varying amounts at the piers and, where possible, at intermediate points, thereby inducing negative moment over the whole length. The slab is then concreted and subsequently the girders are lowered to their final positions, thus producing compression in the concrete and, incidentally, compensating for shrinkage and creep.

The second method comprises prestressing the concrete, either over the supports only or over the whole length, when any of the usual systems are used, e.g. Freyssinet or Leoba (Professor Leonhardt's method). When long carriageways are prestressed it is necessary to jack the tendons from beneath the slab, the ends being curved downwards for this purpose. Beneath footpaths, where there are a few inches of fill, the ends may be curved upwards.

It is also possible to prestress composite girders before the slab is connected to the steelwork, as will be shown later.

Examples of Composite Bridges

The Werratal Autobahn Bridge, Hedemünden[15]

One superstructure for this bridge, constructed by Stahlbau Rheinhausen, has already been described. The other was built in composite construction by M.A.N. a progress photograph being shown in Fig. 11.

The two continuous main girders, built in HSB 50, are 18 ft. deep, the web thickness being 0.56 in. over the supports and 0.48 in. elsewhere. Channels and angles provide the stiffeners and the girders are braced transversely at 26 ft. centres.

The total weight of steel is 950 tons. The combined weight in the two superstructures is 2,505 tons, compared with 3,900 tons in the old bridge.

The top flanges of the girders were provided with bar and stirrup shear connectors at 24 in. centres. The 10 in. slab of quality B.450 concrete was prestressed transversely on the Leoba system and longitudinally by lowering the central portion of the bridge.



Fig. 11.—Werratal Bridge

Initially, the steel girders were erected to the levels shown in the top diagram of Fig. 12. In 35 days, 1,900 cub. yd. of concrete were laid to a carefully planned programme. A month later the longitudinal prestressing commenced. The movement of the girders at the supports to the positions shown in the lower diagram of Fig. 12. was accomplished by the steelwork contractors in 14 days. When it is realised that the whole superstructure weighs 5,100 tons and that one end was raised 10.6 ft., the work involved can be truly appreciated.

The resulting precompression in the concrete over the supports amounted to 900 lb. per sq. in.

The Sulzbachtal Bridge[31]

The superstructure of the new Sulzbachtal Bridge, opened in 1954, has the same appearance as the first bridge, which was completed in 1936.

This bridge which has seven spans of 133 + 171 + 190 + 209 + 190 + 171 + 133 ft., with a total length of 1,197 ft., and a maximum height of 125 ft., is supported, as formerly, by hinged portal frame piers.

The carriageway of the old bridge was supported by stiffened curved plates (*Tonnenbleche*). The new superstructure, Fig. 13, is in composite construction, the welded continuous main girders being in St.52 and the concrete being of quality B.450.

The web plates of the main girders have a constant depth of 9.84 ft. and a thickness of 0.56 in. Except at the piers, where there is extra strength, transverse stiffeners are provided at 9.5 ft. centres, i.e. at every other cross-girder, and longitudinal stiffeners at one-quarter and one-half of the depth.

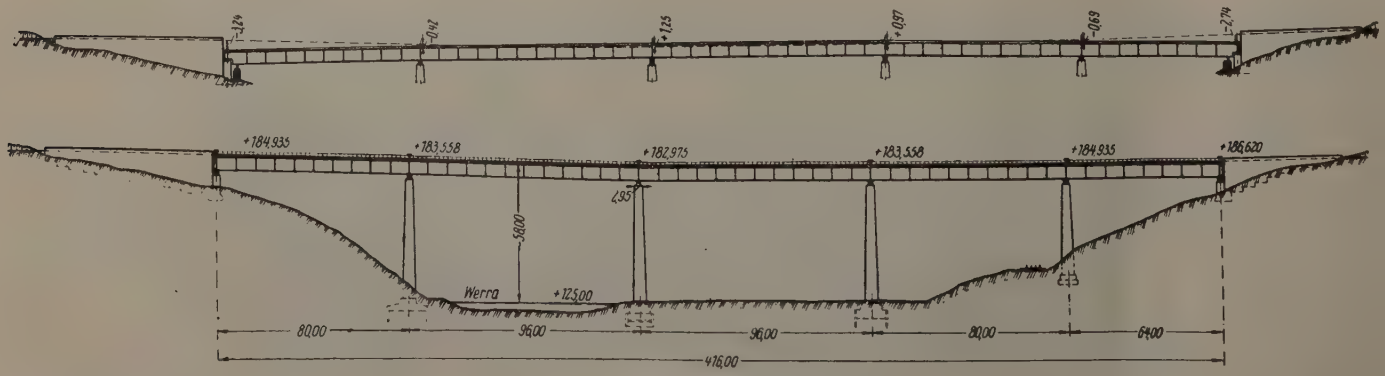


Fig. 12.—Werratal Bridge

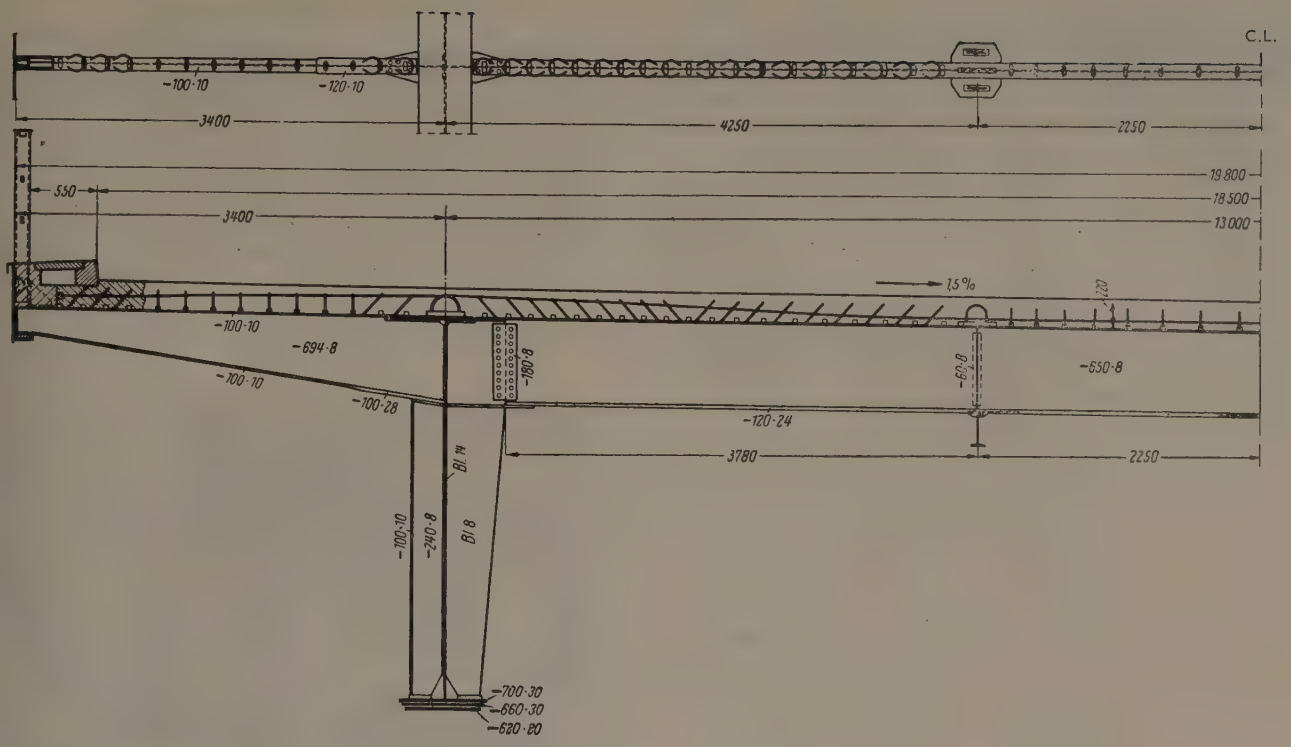


Fig. 13.—Sulzbachtal Bridge

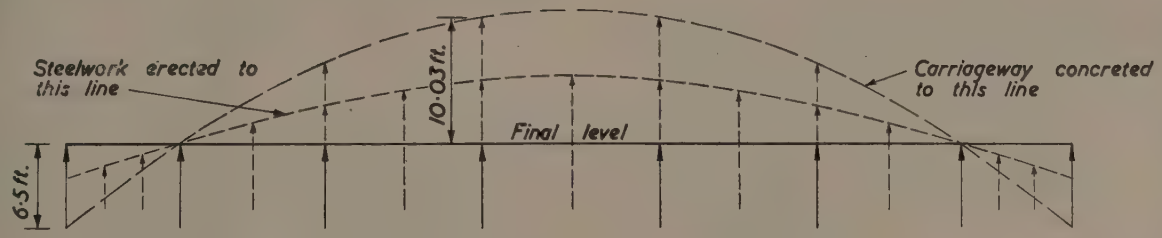


Fig. 14

Although the bridge is now level, the steelwork was initially erected with a slight upward vertical curve, obtained by jacking the feet of the four innermost piers, and by temporary intermediate props. Before concreting commenced, this curvature was increased, as shown in Fig. 14. When the slab had hardened, the composite bridge was lowered to its final position.

The carriageway was also prestressed transversely and longitudinally along its whole length using Sigma St.145-165 wires on the Freyssinet system.

It is of interest to compare the quantities used in the old and the new superstructures, as shown in Table 6, especially as the maximum design load has been increased from 24 to 60 tons.

The main contractors were August Klönne with Dortmunder Brückenbau for the steelwork and Wayss and Freytag with G. Barasel for the prestressed concrete.

Canal Bridge, Lauffen am Neckar

Professor Dischinger[32] and others have suggested various schemes in which prestressed steelwork is used in composite construction. The Montabaur autobahn bridge, described by Wenk,[33] is an example using Dischinger's proposals. Another novel scheme is the superstructure, with a single span of 112 ft., built to replace one span of a viaduct over a canal at Lauffen am Neckar.

The bridge comprises two girders in St.52, 5.67 ft. deep, with adequate bracing, the top flanges being provided with the usual shear connectors and the bottom consisting of a square box containing four prestressing cables, each composed of 52 Sigma St.145—165 wires, 5.2 mm. in diameter.

The steel superstructure was erected on the adjacent span and then rolled into position over a temporary central support. The cables were then prestressed with a force of 310 tons per girder. Then the carriageway and footpaths were concreted, during which time the temporary central support provided an upward force of 50 tons. Subsequently, the central support was removed and the whole superstructure lowered on to its bearings.

Appropriate stress diagrams for all these phases are given by Burkhardt in his article.[34]

The 9 in. thick carriageway slab was prestressed transversely to prevent cracking and covered with 2.4 in. of asphalt.

The scheme was submitted by Stahlbau Rheinhausen in competition with three other schemes in composite construction and four in prestressed concrete. The tender sum was second among the composite schemes and very slightly higher than the cheapest prestressed concrete scheme.

Other Examples

The bridges so far described in this section have been plate girder bridges, but it must not be imagined that composite construction has not been applied to other types. Since 1950, many truss and tied-arch bridges have been erected in which the concrete carriageways and footpaths have been composite with some or all of the supporting steel members. Specific examples[35—6] have been described while Wittmack[37] has given a table showing twelve different types.

About two years ago a novel superstructure was erected across the Mittelland Canal at Minden by Dortmunder Union Brückenbau.[38] The steelwork, which was completed in the workshops, was constructed in the shape of a letter U with shear connectors at the ' serifs.' The steelwork was launched into the canal and hauled to the site by two tugs, the journey taking two days. There, the canal was closed for only two hours while the steelwork was hoisted, pumped out and erected on specially prepared abutments. Subsequently, the concrete road was laid, the total width being 37 ft. The steelwork was 222 ft. long and weighed 100 tons.

Single-Girder Bridges

The feasibility of constructing bridges with a single supporting member was discussed by Haupt[39] and Schmidt[40] in 1948 and 1949 respectively. Since then, Dortmunder Union Brückenbau have submitted special schemes, albeit unaccepted schemes, for large bridges in which single sets of suspension cables or cable bracing were employed. However, two small practical examples [41—2] have been constructed, both being footbridges supported by a single tied-arch.



Fig. 15.—Hase Footbridge, Meppen

Fig. 15 shows the footbridge over the Hase at Meppen.

Two stout cross-girders are provided at the supports, but otherwise a section of the lower part of the bridge consists of a small trapezoidal box with wings carrying the footpaths and parapets.

The complete superstructure, 120 ft. long, was slung into position by a small floating-crane.

Truss and Lattice Girder Bridges[43—4]

The increased use of welding and the ability to handle very long or large sections of steelwork has revolutionised the design of these bridges, which are used for both railways and highways.

As evolved at present the top boom and other compression members are of welded rectangular box section while the bottom booms are similar or of ' top-hat ' section. Other tension members are usually of H section. The principal point of interest is that the gusset plates form part of the webs of the booms, the web members being site-bolted to them.

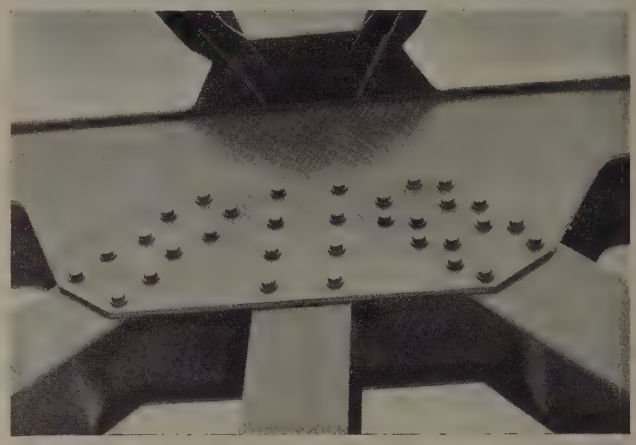


Fig. 16

The example shown in Fig. 16 has the additional interest that it forms part of the first German railway bridge employing high-tensile bolts.[45] At the ends of the compression web members, two opposite plates are bent inwards, so that an H section is formed, the object being to facilitate site bolting.

About 1880, narrow-meshed lattice girders enjoyed some popularity, but subsequently they were entirely abandoned. They are now regaining favour[46] as is shown by the railway bridge at Engers-Urmitz over the Rhine in Fig. 17. The main span is 617 ft. long, the girders being 39 ft. high at 30 ft. centres. When the adjoining spans are completed in the same construction, the bridge will carry two tracks.

The main span shown was built by M.A.N., 2,600 tons of St.52 and St.37 being used.



Fig. 17.—Engers-Urmitz Bridge

STEEL STRUCTURES

Despite the fact that in Germany reinforced concrete has largely replaced structural steelwork for such lightly-loaded structures as flats and offices, the greatest field of application for steel is in buildings and industrial structures. Developments, however, have been less spectacular and rather slower in structures than in bridges. Nevertheless, knowledge gained in the design and construction of bridges has been applied to some of the very large structures.

Multi-Storey Buildings[47]

Framing

In Great Britain we are accustomed to the use of simple construction in which the joints between beams and columns are assumed to be hinged. In Germany, even before the war, it was not uncommon to use rigid construction in which the joints were reinforced by triangular fillets and the actual connections were made with bolts or welds.

For reasons of steel economy and in order to make steel competitive with reinforced concrete, this trend has continued, buildings being constructed either completely rigid or with a mixture of rigid and simple construction. Some examples are shown in Fig. 18. The absence of bracing gives freedom for glazing external walls and placing internal partitions.

The design of the joints is naturally of great importance. Joints are now less cumbersome than formerly, but it is apparent that finality in design has not yet been reached.

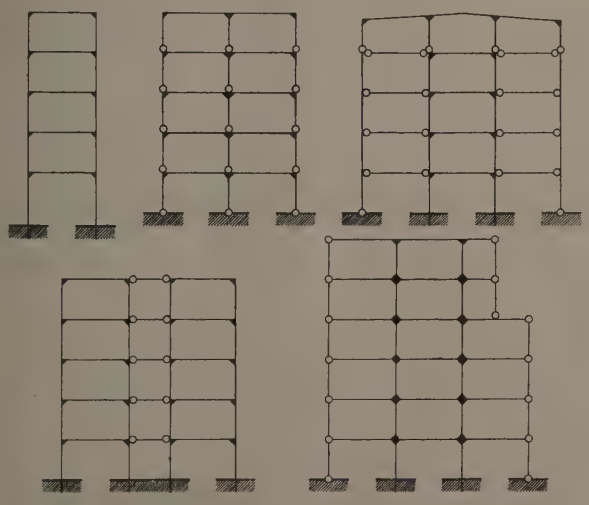


Fig. 18

Floors and Roofs

It has been demonstrated that the two dominant forms of construction for bridges are composite beams and steel decks. In structures, both composite construction and cellular steel floors are being used.

The Standard for composite construction in buildings, DIN 4239, was issued in 1954. It is natural that the provisions should be more simple than those in the bridge Standard, DIN 1078, but the principles are similar.

The most important provision is the division of composite beams into two groups, the first of which comprises statically determinate floor and roof beams up to 16 in. in depth. In such beams it is necessary to calculate the stresses in the top surface of the concrete and in the bottom flange of the steel, but unnecessary to check for shrinkage or creep. The second group comprises all other composite beams, for which it is necessary to calculate the stresses with and without the effect of shrinkage and creep.

Cellular decks, such as in Fig. 19, have a number of advantages over the conventional concrete floor. They are erected with the skeleton, serve as working platforms and provide protection for workmen. The stiffening effect is immediate. The reduction of dead load, up to 60 per cent of the weight of a concrete floor, is useful for large spans, restricted construction depth and poor load-bearing soils.

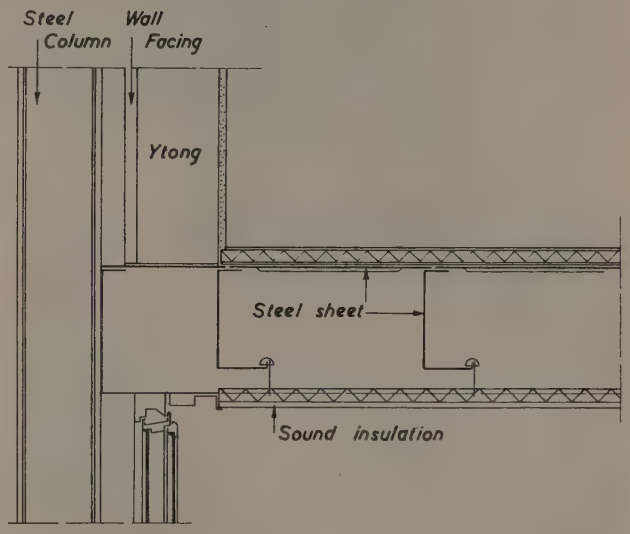


Fig. 19

Columns

For columns, it is likely that the use of tubes or fabricated hollow sections will increase, especially when they are filled with concrete where DIN 1050 permits an increase of one-third in the carrying capacity of the column.

A comparatively recent innovation, which removes the necessity for fire encasement, allows continuous glazing, increases internal space and is aesthetically pleasing, is to place the external columns outside the walls, as shown in Fig. 19. Such columns require regular repainting, but it is claimed that the advantages of the system outweigh this disadvantage.

Curtain Walls

Curtain walling has just reached Germany. A striking twenty-four storey building, the model of which is shown in Fig. 20, is now being built for Mannesmann on the Rhine embankment in Düsseldorf. The framework, not unnaturally, consists of welded tubes and the curtain walls will comprise vitreous enamelled steel sheets in the traditional blue and white of the Company.



Fig. 20.—Mannesmann House

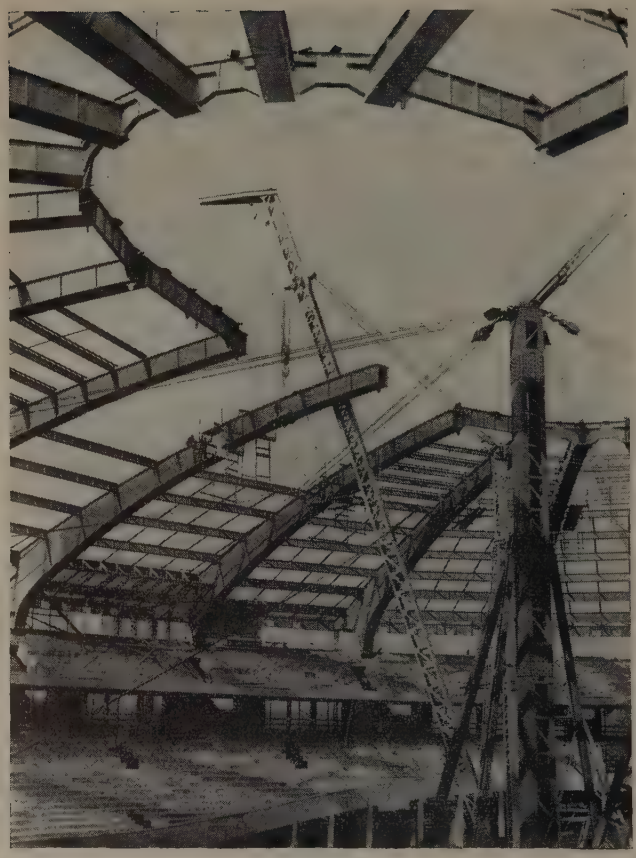


Fig. 22

Exhibition and Sports Halls

Five or six years ago a number of exhibition and sports halls were erected, each containing a large tonnage of steel. Two will be described.

The Westphalia Hall, Dortmund[48]

The new Westfalenhalle, Dortmund, shown in Figs. 21 and 22, is elliptical in plan, the major and minor diameters being 384 and 322 ft. respectively.

The foundations and substructure are in reinforced concrete, but the roof is supported by twenty radial steel ribs of box section, as shown in Fig. 22.

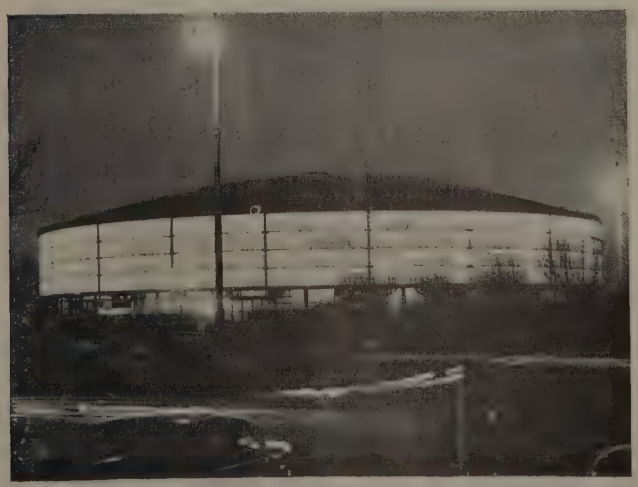


Fig. 21.—Westphalia Hall, Dortmund

The ribs, each of which is tied on the outside of the hall by five bars, project about 100 ft. into the hall where they are held apart by an elliptical frame, above which is a light welded roof and below which is suspended an artificial lighting feature.

The purlins are connected to the ribs, which are in riveted and bolted construction, through slotted holes which take up any movement in the roof.

The roof glazing comprises glass prisms. The remainder of the roof is covered with light-weight concrete and insulation which includes aluminium foil. The wall glazing comprises 4,000 panes, 1 m. square.

The total weight of steelwork is 1,700 tons.

The steelwork was erected by Dortmunder Union Brückenbau and Dortmunder Brückenbau C. H. Jucho.

The Hall of Europe, Hanover[49]

In Hanover, a group of large exhibition halls were built about 1950 to house the German Industries Fair. Hall 9, the Europahalle, is shown in Fig. 23.

The roof is supported by seven two-hinged frames, 277 ft. in span, at 66 ft. centres. Plate girder purlins are spaced at about 23 ft. centres.

The frames, which are of welded box section, are 20 in. deep at the springings, 80 in. at the haunches and 40 in. at the ridge.

The hall is 525 ft. long. The weight of St.37 in the hall and staircases is 720 tons, equivalent to 11 lb. per sq. ft. of floor area.

It is interesting to note that Hall 7 at Leipzig, erected about 1927, which has a span of 318 ft. and almost the same area, contains 1,800 tons of St.48.



Fig. 23.—Hall of Europe, Hanover

The steelwork was designed by Louis Eilers of Hanover and erected by them in conjunction with Eggers of Hamburg.

Industrial Buildings[50]

Buildings in General

The widespread damage during the war gave the Germans the opportunity to rebuild many of their industries from scratch, as a result of which they now possess some of the most modern and well-equipped structures in the world.

In general, the developments in construction have followed the trends revealed just before the war. One factor which has a great influence on structural design is the risk of mining subsidence which prevails in industrial regions such as the Ruhr. There, some ingenious construction, usually of the cantilever and suspended-span type, is employed. Elsewhere, rigid frame and other welded continuous construction is used to a much greater extent than in Great Britain.

Where saw-tooth construction is not employed, roofs are flat or very low in pitch. The Germans have the advantage of a wide range of rolled sections, up to 1 m. in depth, and these, together with light slender plate girders, are used for roofing factories or works. As a consequence, triangulated trusses, except of tubular construction, are used much less than formerly.

The August-Thyssen wide-strip mill at Duisburg-Hamborn is one of a number of buildings having the high-low roof construction with which engineers are familiar at the Abbey Works, S. Wales.

Elsewhere monitor lighting is usual, either transversely or longitudinally while walls are extensively glazed. This is in marked contrast to American practice, where the tendency is to work entirely by artificial lighting.

Inside, buildings have been designed with a far less utilitarian appearance than formerly. Architectural design has extended to machines and plant, as will be seen from the crane in Fig. 24, which is typical of the work of Demag.

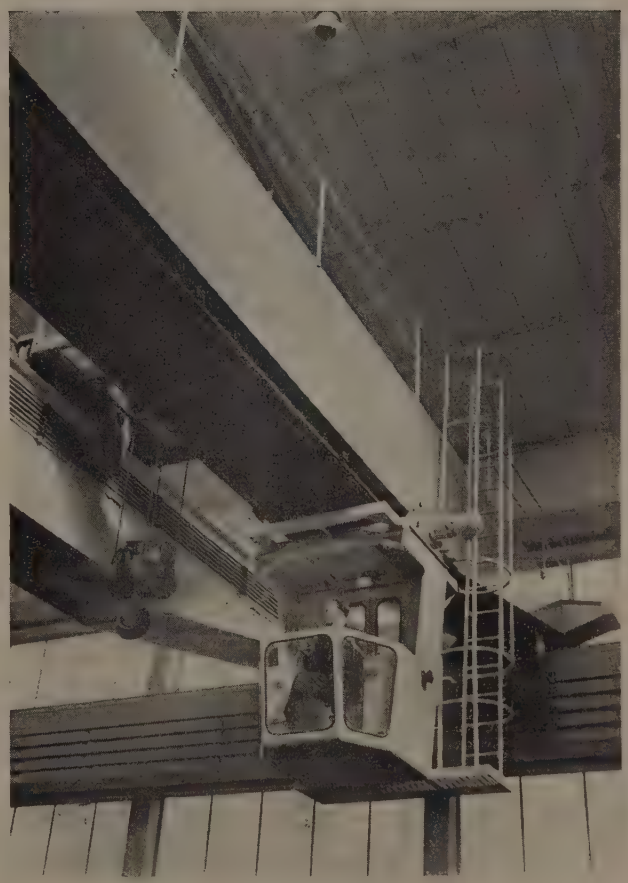


Fig. 24

Plate Girders

As plate girders play such a large part in structures, particularly in steelworks and fabricating shops where gantry crane loads are very heavy, it may not be inappropriate to mention them here.

Stability calculations for all deep slender webs are made in accordance with DIN 4114, which gives fifteen sets of conditions of stress for the design of transverse and longitudinal stiffeners.

Flange plates, such as the Dörnen, Nasen or Krupp-ST profiles, specially rolled for welding, are now much less popular. Dörnen produces girders in which equal angle sections are welded between the flange and web plates, the toes being welded to the flange and the corner to the web. Another method is to split broad flange beams down the middle and to weld in a web plate, a process suitable for automatic welding.

Both mild and H.T. steels can be used in the same girder. In composite construction, for example, where the neutral axis is high, the tensile stresses are much greater than the compressive.

It may be of interest to record that for gantry girders up to 1 m. in depth it is common practice to include 75 per cent (i.e. allowing for wear) of the section of the rail in computing the geometrical properties of the girder. The German manual *Stahl im Hochbau* gives appropriate tables for girders in which flat-bottomed rails are bolted to sections consisting of joists and channels. The bolt spacing may be less than usual, but an increase of 10—15 per cent may be obtained in the value of Z.

Considerable progress has now been made with flangeless driving wheels on overhead cranes. Pressure rollers, acting horizontally on the top flanges of the girders, take the side thrust.

Tubular Construction

Tubes, traditionally used for pipelines, are now used extensively for structures.

One of the largest tubular structures yet erected in Germany is the goods station at Wanne-Eickel, shown in section in Fig. 25, in which Mannesmann St.55 tubes were used for the trusses, bracing and monitors. As the area is subject to mining subsidence, one hollow column, consisting of welded tapering plates, is rigidly fixed to the truss, while the other, comprising two channels welded toe to toe, is hinged at both ends. The trusses, which are at 36 ft. centres, support asbestos cement sheets and glazing. The weight of steelwork for the building, which is 590 ft. long and covers an area of 99,000 sq. ft. is 390 tons, or 8.8 lb. per sq. ft.

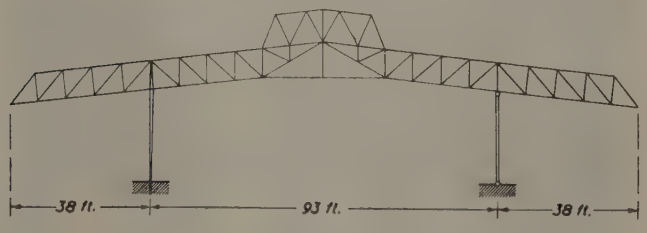


Fig. 25

Professor Fritz of Karlsruhe[51] has been developing prestressed tubular construction. Among a number of suggested schemes is a truss, triangular in section, comprising two tubular top booms, supporting a deck or roof, connected by triangulated bracing to a single bottom boom, which is prestressed by bars passing through it.

Some practical examples already exist. There seems to be little reason why the system should not be extended to very large spans. Long lengths of prestressed boom can be made up by employing diaphragms and sleeves. The system can be used for continuous structures by prestressing the top booms over the supports.

Spherical Gas Holders

Many towns in the Rhineland and elsewhere obtain their supplies of gas from the coke ovens associated with steelworks. During the last two years, August Klönne have erected three almost identical spherical gas holders in two Cologne suburbs, in which Ruhr gas is stored at 5½ atmospheres.

Each holder has the following properties :

Diameter	— 110 ft.
Volume	— 3½ million cub. ft.
Number of plates	— 146.
Thickness of plates	— 1.2 in.
Maximum sizes of plates	— 24 ft. × 12 ft. × 5.8 tons.
Support for sphere	— 15 pairs of tubes, 50 ft. long and 20 in. in diam.
Total weight of steel	— 950 tons of HSB 50 and FB 50.

The plates were tested for laminations by the mills and by the Contractor. The welds were tested by X-rays, 4,000 tests being made on 6,000 ft. of weld in one holder, with less than 1 per cent bad results.

In the initial stages, until the welded tubular supports could be used, the lowest plates were supported by a vertical derrick acting as the central axis of the sphere. The plates were correctly aligned by the use of temporary curved fingers connecting adjacent plates.

The tops of the plates provide constant "lines of latitude." The sides are irregular.

High Tensile Bolts

Formerly, H.T. bolts were used in Germany to hold down machinery, but as a result of research at Technical High School, Karlsruhe, their use is being extended to bridges and structures where they will reduce the problem caused by the shortage of riveters.

The Karlsruhe investigations are continuing, but the first report[52] which gives, inter alia, the frictional resistance of various kinds of surface, includes also the following recommendations for the use of H.T. bolts in structures :

1. Quality 10 K steel (U.T.S. 58 tons/sq. in.) shall be used for bolts and quality 6 S (U.T.S. 38 tons/sq. in.) for nuts. Washers, which must be used at the head and nut, shall be 8 mm. (0.32 in.) thick with an inner diameter equal to that of the bolt hole and an outer twice as large. Their surface shall be heat-treated to obtain the same hardness as the nuts. At least one washer should be bevelled. (Author's note—Presumably this relates to joists and channels with bevelled flanges).

2. For tightening the nuts the following torques are recommended (assuming that the bolt and nut are phosphated or similar) :

	Rolled Steel tons	Cast Steel tons	Reinforcement tons	Wire tons	Concrete cub. ft.
First bridge	3817 St.37	248	50	—	55,800
Second bridge	947 St.37 596 St.52	248	104	98	58,200

Bolt ∅ mm. (ins.	12 0.48	14 0.56	16 0.64	18 0.72	20 0.80	22 0.88	24 0.96)
Torque kg.m (lb. ft.	8.5 62	13.7 99	21.6 156	29.5 212	42.1 303	58.1 418	72.8 524)

Table 6.

3. Contact surfaces should be flame-cleaned with a feed speed of approx. 1 m/min. directly before assembling. Any residue on the surface can be removed by light brushing. (Whether the flame-cleaning should be replaced by sand blasting or similar treatment can be considered in the future).

4. The bolt holes may be up to 1 mm. larger than the nominal diameter of the bolt. Reaming of the parts to be joined before tightening is not necessary if marking and boring are efficient.

5. Tightening of bolts must be carefully controlled and recorded. It is advisable to check at random up to 10 per cent of the bolts by short loosening and screwing up again to a marked point of the nuts.

6. Until further tests have been carried out, such joints are to be rated as riveted joints in which the rivet is given the same diameter as the rivet hole.

The recommendations with regard to flame-cleaning are stringent. Formerly, it was usual in the U.S.A. to check 10 per cent of the bolts at random, but this practice is no longer common.

Fig. 16 shows an example of a joint incorporating H.T. bolts.

A revolutionary extension of the use of H.T. bolts in structures is a joint in which the contact surfaces are coated with a thin layer of a polyester compound which hardens in about one hour and which provides or augments the frictional strength normally given by H.T. bolts.

Dörnen and Trittler[53] have described the construction of a pipe bridge at a chemical works, 184 ft. in span, in which this new form of connection was employed. The new adhesive resists inclement weather and is effective in the temperature range—30 to +100° C.

Bibliography

[1] Mason, J., " Report on Structural Engineering in Germany," *The Structural Engineer*, June, 1946.

[2] Schaper, G., " Leichte Fahrbahndecken und leichte Fahrbahntafeln für stahlerne Strassenbrücken," (" Light Decks for Steel Highway Bridges "), *Die Bautechnik*, January, 1935.

[3] Chettoe, C. S., " Some Notable German Bridges," *Civil Engineering*, June and July, 1953.

[4] Cornelius, Dr. W., " Die Berechnung der ebenen Flächentragwerke mit Hilfe der Theorie der orthogonal-anisotropen Platte," (" The Calculation of flat Frameworks with the help of the Theory of Orthogonal-Anisotropic Plates "), *Der Stahlbau*, February to April, 1952.

[5] Giencke, E., " Die Grundgleichungen für die orthotrope Platte mit exzentrischen Steifen," (" The Fundamental Equations for Orthotropic Plates with Eccentric Stiffeners "), *Der Stahlbau*, June, 1955.

[6] Fischer, G., " Die Berechnung der Fahrbahntafel der Bürgermeister-Schmidt-Brücke in Bremen," (" The Calculation of the Deck for the Bürgermeister Schmidt Bridge in Bremen"), *Der Stahlbau*, November, 1952.

[7] Sievers, Dr. H., " Der Wettbewerb für den Wiederaufbau der Strassenbrücke über den Rhein zwischen Duisburg-Ruhrort und Homberg," (" The Competition for the Reconstruction of the Highway Bridge over the Rhine between Duisburg-Ruhrort and Homberg "), *Der Stahlbau*, January, 1953.

[8] Die Neue Köln-Mülheimer Brücke, *Hubert Ganter*, Köln, 1951.

[9] Lamster, A. and Stoltenburg, Dr. W., " Neubau der Bürgermeister-Schmidt-Brücke in Bremen," ("The New Bürgermeister Schmidt Bridge in Bremen"), *Der Stahlbau*, November, 1952.

[10] Tussing, F. and Rohrbach, C., " Dehnungsmessungen an Teilen der Fahrbahnplatte der Rheinbrücke Düsseldorf-Neuss mit Dehnungsmessstreifen," (" Strain Measurements on parts of the Deck of the Düsseldorf-Neuss Bridge with Strain Gauges "), *Der Stahlbau*, March, 1953.

[11] Lange, K., " Über den heutigen Stand der Stahlbrückenbaues unter besonderer Berücksichtigung der Schweisstechnik," (" The present position of Steel with particular reference to Welding Techniques "), *Schweissen und Schneiden*, June, 1952.

[12] Stüssi, Prof. F., " Der dünnwandige schlanke Stahlstab mit Kastenquerschnitt," (" The Thin-Walled Slender Steel Member with Box-Section "), *Publications I.A.B.S.E., Eleventh Volume*, 1951.

[13] Massonnet, Prof. C., " Tensions de Cisaillement dans les Pièces Fléchies Centre de Cisaillement," (" Shear Stresses in Members Bent about their Shear Centre "), *Commission pour l'Etude de la Construction Métallique* (*C.E.C.M.*), Belgium, Technical Note B-10.31.

[14] Daniel and Warolus, " Calcul des Entretoisements d'un Pont à Poutres-Maitresses en Caisson," (" Calculation of the Bracing for a Bridge with Main Girders of Box Section "), *C.E.C.M.*, Technical Note C-11.

[15] Seetzen, U., " Die Autobahnbrücke über die Werra bei Hedemünden," (" The Autobahn Bridge over the Werra at Hedemünden "), *Die Bautechnik*, January, 1953.

[16] Ehnert, Dr. G. and Krosse, H., " Die wiedergestellte Autobahnbrücke bei Hedemünden, Stahlüberbau oberstrom," (" The Upstream Steel Superstructure of the Reconstructed Autobahn Bridge at Hedemünden "), *Der Stahlbau*, July, 1953.

[17] Dörnen, Prof. A., " Stahlüberbau der Weserbrücke Porta," (" The Steel Superstructure of the Weser Bridge, Porta "), *Der Stahlbau*, May, 1955.

[18] Schlüssler, K. and Pelikan, Dr. W., " Die Neue Rheinbrücke Köln-Mülheim," (" The new Köln-Mülheim Bridge over the Rhine "), *Der Stahlbau*, December, 1951.

[19] Vogel, G., " Montage des Stahlüberbaues der Rheinbrücke zwischen Duisburg-Ruhrort und Homberg," (" Erection of the Steel Superstructure of the Rhine Bridge between Duisburg-Ruhrort and Homberg "), *Der Stahlbau*, June, July and September, 1955.

[20] Sievers, Dr. H. and Görtz, W., " Der Wiederaufbau der Strassenbrücke über den Rhein zwischen Duisburg-Ruhrort und Homberg," (" The Reconstruction of the Rhine Highway Bridge between Duisburg-Ruhrort and Homberg "), *Der Stahlbau*, April, 1956.

[21] Sievers, Dr. H. and Bornscheuer, E., " Über der Beulstabität durchlaufender Platten mit drehsteifen Längsteifen," (" The Stability of Continuous Plates with Torsion-Resisting Longitudinal Stiffeners "), *Der Stahlbau*, July, 1953.

[22] Forestier,V., " Le calcul des constructions mixtes acier-béton," (" The calculation of composite structures "), *Centre Belgo-Luxembourgeois d'Information de l'Acier*, 1949.

[23] Soete, A., " Les constructions mixtes acier-béton," (" Composite Construction "), *C.E.C.M.*, Technical Note C-12.

[24] Sattler, Prof. K., " Theorie der Verbundkonstruktionen," (" Theory of Composite Construction "), *Wilhelm Ernst*, Berlin, 1953.

[25] Schrader, Dr. H. J., " Vorberechnung der Verbundträger," (" Preliminary Calculation of Composite Beams "), *Wilhelm Ernst*, Berlin, 1955.

[26] Froelich, Dr. H., " Theorie der Stahlverbundtragwerke," (" Theory of Composite Steel Frames "), *Der Bauingenieur*, March, 1950.

[27] Klöppel, Prof. K., " Die Theorie der Stahlverbundbauweise in statisch unbestimmten Systemen unter Berücksichtigung

des Kriecheinflusses," (" The Theory of Composite Construction in Statically Indeterminate Systems in relation to the Influence of Creep "), *Der Stahlbau*, February, 1951.

[28] Wrycza, W., " Verbundbauweise mit und ohne Vorspannung unter Berücksichtigung des Schwind-und Kriecheinflusses auf die statisch unbestimmten Systeme, Mit Zahlenbeispielen," (" Composite Construction with and without Prestressing in relation to the Influence of Shrinkage and Creep on Statically Indeterminate Systems. With Worked Examples "), *Die Bautechnik*, August—September, 1954.

[29] Rüsch, Prof. H., " Die mitwirkende Plattenbreite bei Plattenbalken," (" The Effective Breadth of T-Beams "), *Der Stahlbau*, January, 1953.

[30] Klingenberg, Dr. W., " Schubsicherungen," (" Shear Connectors "), *Der Bauingenieur*, March, 1950.

[31] Homberg, Dr. H., " Die neue Sulzbachtalbrücke der Autobahn," (" The new Sulzbachtal Autobahn Bridge "), *Der Stahlbau*, September, 1954.

[32] Dischinger, Prof. F., " Stahlbrücken in Verbund mit Stahlbetondruckplatten bei gleichzeitiger Vorspannung durch hochwertige Seile," (" Reinforced Concrete Slabs Composite with Steel Bridges Prestressed with High-Strength Cables "), *Der Bauingenieur*, November and December, 1949.

[33] Wenk, H., " Neubau der westlichen Fahrbahnseite für die Autobahnbrücke bei Montabaur," (" The new West Superstructure for the Montabaur Autobahn Bridge "), *Der Stahlbau*, June, 1954.

[34] Burkhardt, Dr. E., " Strassenbrücke über den Schiffahrtskanal zu Lauffen am Neckar," (" Highway Bridge over the Canal at Lauffen am Neckar "), *Die Bautechnik*, July, 1955.

[35] Roloff, H. J. and Wittmack, E., " Wiederaufbau der Werner-Strassenbrücke über den Datteln-Hamm-Kanal bei Rünthe," (" The Reconstruction of the Werner Highway Bridge over the Datteln-Hamm Canal at Rünthe "), *Die Bautechnik*, April, 1955.

[36] Bauch, F. and Joos, J., " Strassenbrücke über den Wesel-Datteln-Kanal in Dorsten," (" Highway Bridge over the Wesel-Datteln Canal in Dorsten "), *Der Stahlbau*, November, 1955.

[37] Wittmack, E., " Einige Beispiele zur Entwicklung der Fachwerk-und Stabbogenverbundbrücken," (" Some Examples of the Development of Truss and Tied-Arch Bridges "), *Die Bautechnik*, September, 1954.

[38] Anon, " The Rebuilding of Bridge No. 137 on the Mittelland Kanal at Minden," *Acier Stahl Steel*, June, 1956.

[39] Haupt, W., " Die Mittelträgerbrücke, eine neue Brückenform für den modernen Schnellverkehr," (" The Middle-Beam Bridge, a New Type of Bridge for Modern Fast Traffic "), *Die Bautechnik*, February and March, 1948.

[40] Schmidt, Dr. G., " Über die Knicksicherheit des Obergurtes einer Mittelträgerbrücke," (" The Stability of the Top Flange of a Middle-Beam Bridge "), *Die Bautechnik*, January, 1949.

[41] Haupt, W. and Kleinschmidt, H. J., " Die Alleestrassenbrücke in Wanne-Eickel," (" The Allee Bridge at Wanne-Eickel "), *Der Stahlbau*, January, 1955.

[42] Haupt, W., "Die Fussgängerbrücke über die Hase in Meppen," (" The Footbridge over the Hase in Meppen "), *Der Stahlbau*, June, 1956.

[43] Ernst, Dr. E. and Lemmerhold, F., " Die Brücken-und Ingenieurhochbau der Deutschen Bundesbahn im Jahre 1953' . . . . Jahre 1954' . . . . Jahre 1955," (" Bridges and Structures on the DB in 1953 . . . . 1954 . . . . 1955' "), *Die Bautechnik*, July, 1954, July, August, October, 1955, August, Sept., 1956.

[44] Georg, P., " Der Wiederaufbau der Kaiserbrücke bei Mainz," (" The Reconstruction of the Kaiser Bridge in Mainz "), *Der Stahlbau*, October and November, 1955.

[45] Ernst, Dr. E., " Die Erste Eisenbahnbrücke der Deutschen Bundesbahn mit Vorgespannten, Hochfesten Schrauben als Verbindungsmittel," (" The First Railway Bridge of the DB employing High-Tensile Bolts for Connections "), *Der Stahlbau*, October, 1954.

[46] Wolf, Dr. W., " Die Entwicklung der neuzeitlichen Stahlbrückenbaues in Deutschland," (" The Development of Modern Steel Bridges in Germany "), *Bulletin No. 5 of the Commission of the Swiss Steel Industry (T.K.V.S.B.)*, 1952.

[47] Wolf, Dr. W., " Wichtige Gesichtspunkte für die Ausführung neuzeitlicher Stahlskelettbauten," (" Important Considerations in the Execution of Modern Steel-Framed Buildings "), *Bulletin No. 12 T.K.V.S.B.*, 1955.

[48] Neumann, R., " Der Wiederaufbau der Westfalenhalle in Dortmund," (" The Reconstruction of the Westphalia Hall in Dortmund "), *Der Stahlbau*, May, 1952.

[49] Höber, E., " Die Stahlkonstruktion der Europahalle der Deutschen Industrie-Messe Hannover," (" The Steel Structure of the Europahalle at the German Industries Fair, Hanover "), *Der Stahlbau*, August, 1951.

[50] Henn, Prof. W., " Bauten der Industrie," (" Industrial Buildings "), *Callwey*, Munich, 1955.

[51] Fritz, Prof. B., " Anwendung des Vorspanngedankens bei reinen Stahlkonstruktionen," (" The Application of Prestressing Processes to Pure Steel Structures "), *V. D. I. Zeitschrift*, 1st August, 1956.

[52] Steinhardt, Prof. O. and Möhler, Dr. K., " Versuche zur Anwendung vorgespannter Schrauben im Stahlbau. I Teil," (" Research on the Application of High-Tensile Bolts to Steel Construction. Part I "), *Report No. 18 of the German Committee for Steel Structures*, 1954.

[53] Dörnen, Prof. A. and Trittler, Dr. G., " Neue Wege der Verbindungstechnik im Stahlbau," (" New Techniques for Structural Steel Connections "), *Der Stahlbau*, August 1956.

Appendix 1.

Selected List of German Standards
German Standards Institution

DIN 1000	STEEL STRUCTURES other than Railway and Highway Bridges. Principles of Design.
DIN 1044	REINFORCED CONCRETE STRUCTURES.
DIN 1045	Regulations for the Construction of Structures in Reinforced Concrete.
DIN 1048	Regulations for Testing Concrete in the Construction of Concrete and Reinforced Concrete Structures.
DIN 1050	Bases of Calculation for Steel Structures.
DIN 1055	STRUCTURES. Loading.
DIN 1072	HIGHWAY BRIDGES. Loading.
DIN 1073	Bases of Calculation for Steel Highway Bridges.
DIN 1075	MONOLITHIC BRIDGES. Bases of Calculations.
DIN 1078	COMPOSITE BEAMS FOR HIGHWAY BRIDGES Regulations for Calculation and Erection. Discussion and Explanation.
DIN 1079	STEEL HIGHWAY BRIDGES. Bases for Structural Design.
DIN 1350	SYMBOLS for the computation of stresses.
DIN 4100	WELDED STRUCTURES other than Railway and Highway Bridges.
DIN 4101	Regulations for welded, plate girder Highway Bridges.
DIN 4114	STEEL CONSTRUCTION. Cases of Stability (Buckling, Twisting, Bulging). Principles of Design. Regulations.
DIN 4115	LIGHT— AND TUBULAR—STEELWORK IN STRUCTURES. Regulations for Design and Erection.
DIN 4225	PRECAST UNITS IN REINFORCED CONCRETE.
DIN 4227	PRESTRESSED CONCRETE. Regulations for Design and Erection.
DIN 4239	COMPOSITE BEAMS FOR STRUCTURES. Regulations for Design and Erection.
DIN 4420	SCAFFOLDING REGULATIONS.

German Railways

DV 804	Bases of Calculation for steel railway bridges.
DV 805	Principles for the construction of steel railway bridges.

Acknowledgments

The author wishes to express his most grateful thanks to those engineers and firms who gave him information and photographs and without whose help this paper could not have been prepared. In particular, he would like to thank Dr. W. Wolf and Dipl.-Ing P. Boué of the Deutscher Stahlbau Verband, Köln; Dr. E. Burkhardt, Stuttgart; Professor F. Leonhardt, Stuttgart; Dr. Möhlmann, Würzburg; Demag, Duisburg; Dortmunder Union Brückenbau; Louis Eilers, Hanover; J. Fries und Sohn, Frankfurt-am-Main; Aug. Klönne, Dortmund; M. A .N., Gustavsburg; Mannesmann, Düsseldorf; and Stahlbau Rheinhausen.

Factory in Concrete for the Pressed Steel Co., Ltd., Stratton St. Margaret*

By D. H. New, E.R.D., B.Sc. (Eng.), M.I.Struct.E., M.I.C.E. and R. Sanders, M.I.Struct.E.

Synopsis

THE subject of the paper is the precast concrete frame of the main building for the Pressed Steel Company's new factory at Stratton St. Margaret.

A description of this building is given, together with details of its various precast columns, beams, purlins and wall cladding units with an integral exposed finish. Mention is made of cutting contraction joints in floors subject to heavy trucking.

There are also brief notes on the ancillary buildings, civil engineering works and services.

The paper is sub-divided as follows :

Introduction.
General Description of Site and Structures.
Design Considerations.
Construction Details—
(*a*) Main Structure.
(*b*) Basement.
(*c*) Pre-cast Wall Units.
(*d*) Floors.
(*e*) Erection Data.
Concrete Plant.
Contract Organization.
Notes on Civil Engineering Works.
Notes on Services.
Conclusion and Acknowledgments.

Introduction

By 1954 the Pressed Steel Co. Ltd. of Cowley, Oxford, with its local factory producing motor-car bodies, its factory at Paisley producing wagons for British Railways and overseas, and at Theale, near Reading, Prestcold refrigerators, came to the point where they were again finding the need for further expansion.

Extension to existing sites was not possible for various reasons, but the extensive housing programme at Swindon in connection with the London County Council's re-housing scheme made it possible to obtain Board of Trade approval for development in the area. It was only a few miles further than Cowley, Oxford, from the Company's customers in Coventry and Birmingham.

An Industrial Development Certificate to cover the first stage was issued by the Board of Trade in December 1954, after which negotiations with the local authorities were speedily completed with the result that 135 acres of land at Stratton St. Margaret in the Highworth Rural District Council area were purchased in time for operations to commence on site in February, 1955. The main contractors, Messrs. Holland & Hannen and Cubitts Ltd., working in conjunction with the Pressed Steel Co.'s engineers carried out the complete contract, being responsible for planning and design, and the installation of services.

* *Paper to be read before the Institution of Structural Engineers, at 11, Upper Belgrave Street, London, S.W.1, on Thursday, 28th February, 1957, at 6 p.m.*

At the planning stage, it was evident that as overall completion was required within a period of eighteen months and partial completion within nine, the construction programme would obviously be controlled by the time required for the design, fabrication, delivery and erection of the frame. In addition, considerations of economy were of the utmost importance.

Messrs. Pressed Steel Co. Ltd.'s usual practice had been to build in structural steel. In this instance, however, it was immediately apparent that reinforced concrete framing would be quicker, and after careful consideration they accepted the contractor's assurance that it would compare favourably under service conditions with the existing steel framed structures at Cowley.

General Description of Site and Structures

The whole site occupies an area of 135 acres, 27 of which are covered by the initial development, described in the paper.

The south and west sides are bordered by existing roads and railways, the remainder by farmland. Over the initial development area the ground rises 17 ft. in a northerly direction.

Test bores showed that Corallian Limestone of the Jurassic era was at a depth of 17—20 ft. below surface, overlain by a bed of stiff blue Kimmeridge Clay covered by alluvial brown and mottled clays, having a safe bearing capacity of approximately $1\frac{1}{2}$ and 4 tons per sq. ft. at depths of 5 ft and 12 ft. respectively.

With the exception of the Press Shop Basement, the excavation depth for foundations averaged 7 ft. below finished site level. No natural ground water level was encountered. Shoring was found to be unnecessary unless some time was likely to elapse before the mass concrete was placed in any column base. A basement occupies the majority of the area of the Press Shop, the depth of the excavation being approximately 15 ft. The columns in this area are carried on bored piles.

The main production building covers an area of 300,000 sq. ft. and comprises three sections—the Assembly Shop, the Press Shop, and the Steel Store (Fig. 1). The Assembly Shop is of North Light construction, while the Press Shop and Steel Store have flat roofs.

The super-structure of the main building is precast throughout, having grouted joints, and with a negligible amount of insitu concrete. Site shuttering above ground floor level was almost eliminated by shaping the ends of the units so that they could retain within themselves grout or concrete infilling.

Ancillary Buildings consist of a Boiler House, Compressor House, Oxy-Acetylene House and Gate House. The Boiler House, covering an area of 11,000 sq. ft., the Compressor House, 6,500 sq. ft., and the Oxy-Acetylene House, 4,000 sq. ft. are all in reinforced concrete. These buildings are of precast construction throughout above ground floor level, except for the walls of the Oxy-Acetylene building, which are of insitu

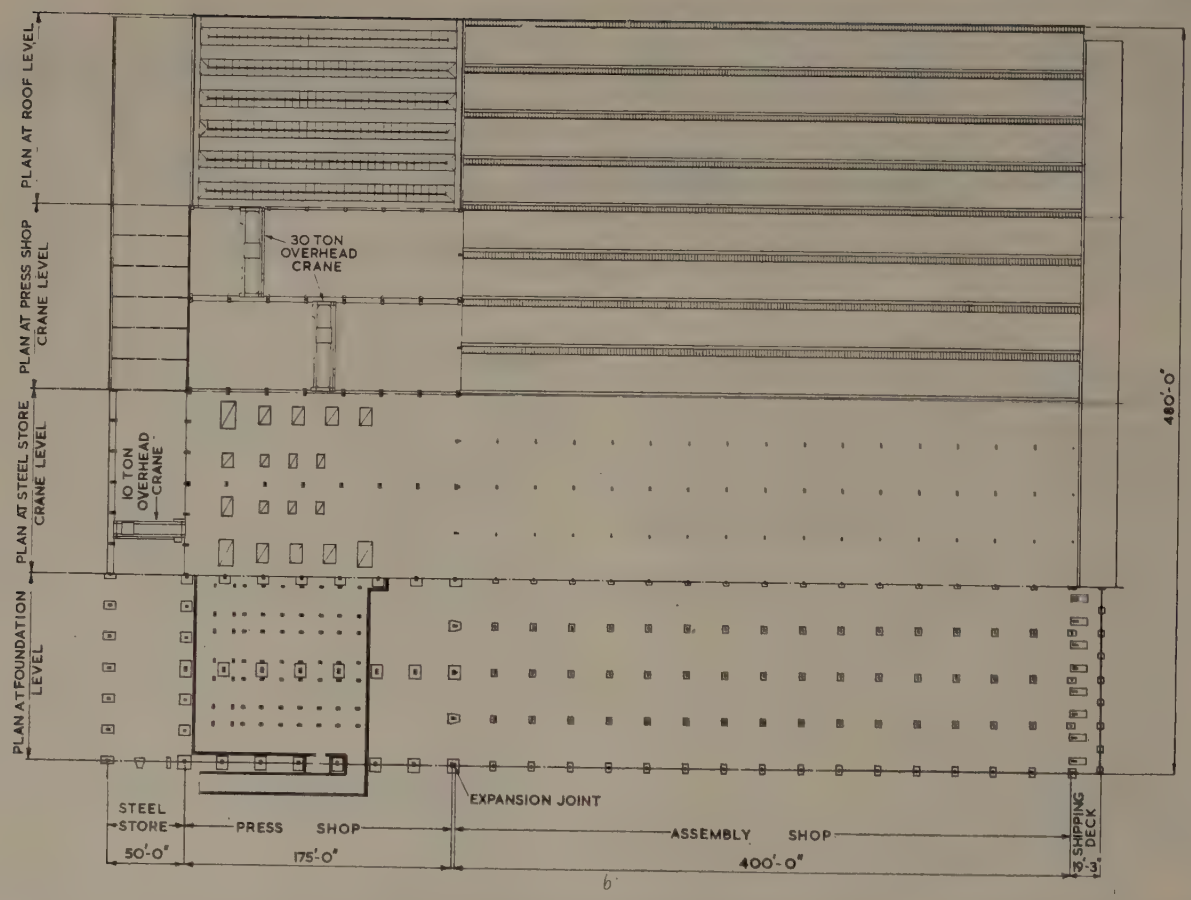


Fig. 1.—Plan of the Main Building



Fig. 2.—The Ancilliary Buildings, showing the high level light steel bridging carrying services to the Main Shop

concrete—the reason for this being that the outline was shaped to the profile of the plant to be housed, in consequence of which it was not economically possible sufficiently to standardise precast wall units. The ancillary buildings, not further described in the paper, are situated north of the main building, and feed works services across high level light steel bridging (Fig. 2).

Access to the site is by road from the south boundary and by rail from the west, the lay-out being as shown on the site plan. (Fig. 3.)

Development beyond the initial stage is already in hand. At the time of writing (October, 1956) a machine shop of 55,000 sq. ft. is under construction, while a workshop and garage, canteen, laboratory, medical and office block are planned for the future.

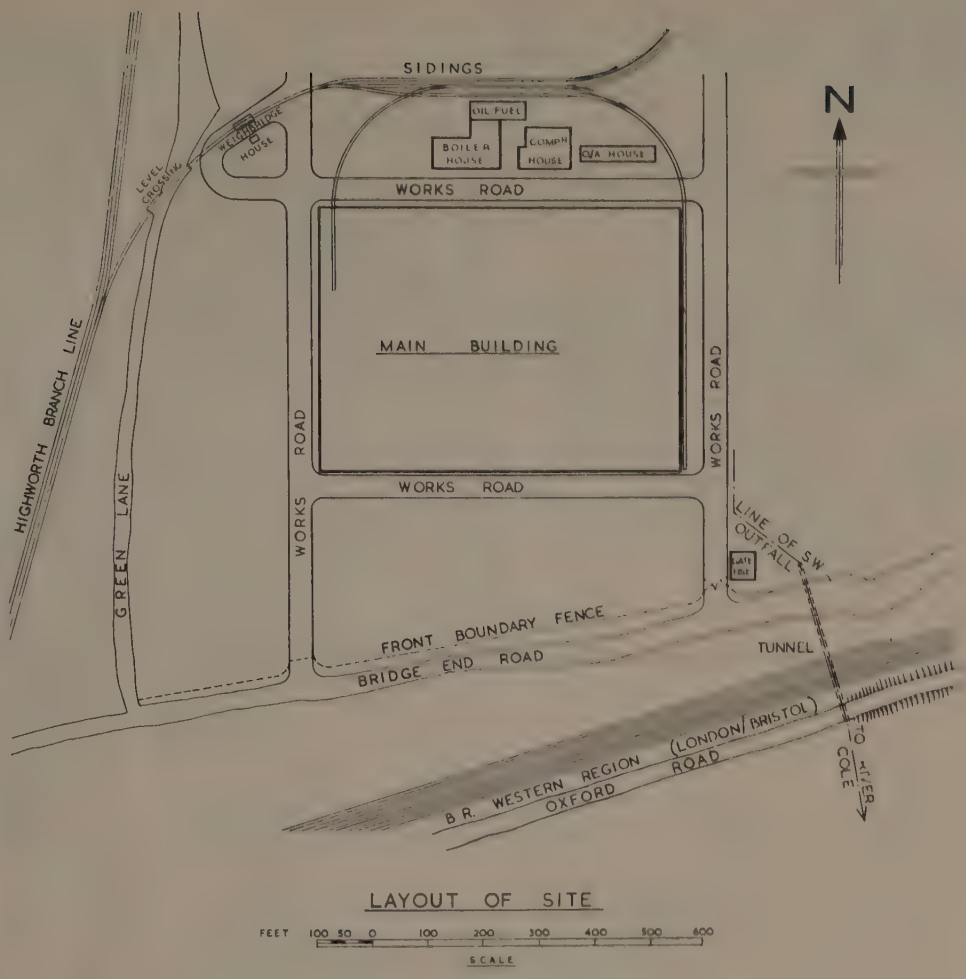


Fig. 3.—Layout of the Site

Design Considerations

It is the opinion of the Authors that after sketch plans of any scheme have been prepared the final design must be based mainly on (a) availability of materials and labour, (b) construction method, and (c) a time schedule covering all trades, inclusive of mechanical services and the delivery dates for factory plant.

Precast reinforced concrete was selected as the main construction material as apart from other considerations reinforcement was readily available. The design then proceeded, taking into account that for speedy erection there should be as few operations as possible. It will be seen from the Figs. 4, 5 and 6 that the superstructure framing could be erected in three main operations, i.e. erection of columns, roof beams and purlins. After this roof covering and glazing could proceed immediately, followed by the installation of mechanical services and factory plant. The basic design was simple due to the fact that all columns were arranged as free standing, cantilevered from the base to take wind and crane thrusts, and by virtue of the dowelled joints, roof members could be taken as freely supported. It should be noted that many of the columns were subject to their maximum stress during handling and when subjected to wind pressure in an unbraced condition, i.e. immediately after erection.

Owing to labour considerations it was particularly advantageous to construct the walls in precast concrete panels weighing up to 4 tons each.

The Consultant Architect, in searching for the best elevational treatment for this material decided to employ alternating coloured rectangles of exposed natural aggregates or mortar, which gave a striking appearance to the completed structure (Fig. 7).

The two ends of the steel store were built in a natural local stone by local craftsmen.

For contracts of this nature, when the order is placed before any working drawings have been prepared the order and speed of erection is determined to a great extent by drawing office procedure. Close collaboration between design and construction staff is essential to ensure the maximum production period within the operational programme. This was maintained by the Planning Engineer on site and the Project Engineer in the Design Office. When it is realised that the contract involved some twelve miles of purlins it will be appreciated that details are required early in order that their fabrication may proceed, even before the issue of foundation details. It will be appreciated also, that the majority of drawing office work is in the external wall construction and because of this, details of the more simple internal work were prepared first, in order that manufacture could quickly proceed for the bulk of the columns and roof members. Subsequently, on the site, erection of internal bays was carried out before external work, thus the order of erection was determined by drawing office procedure.

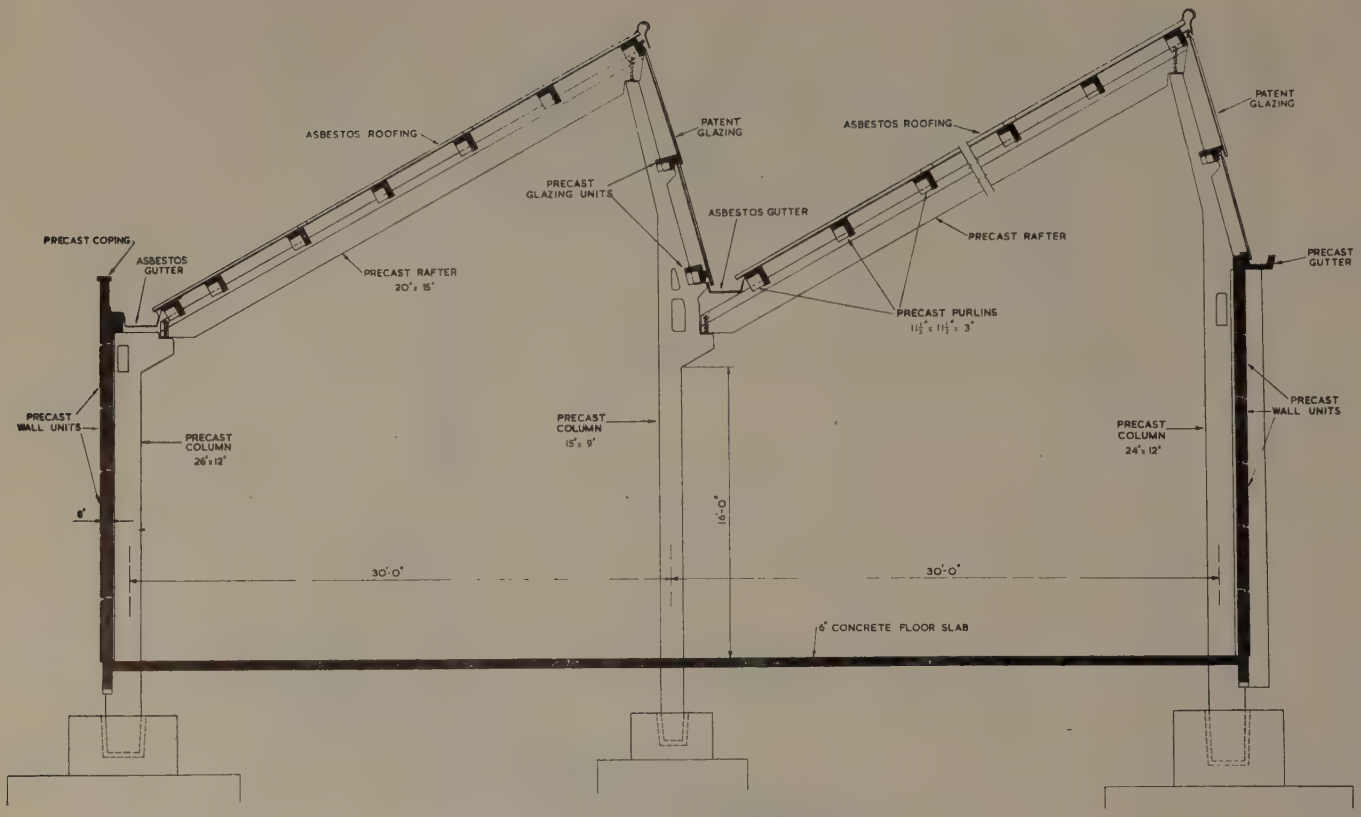
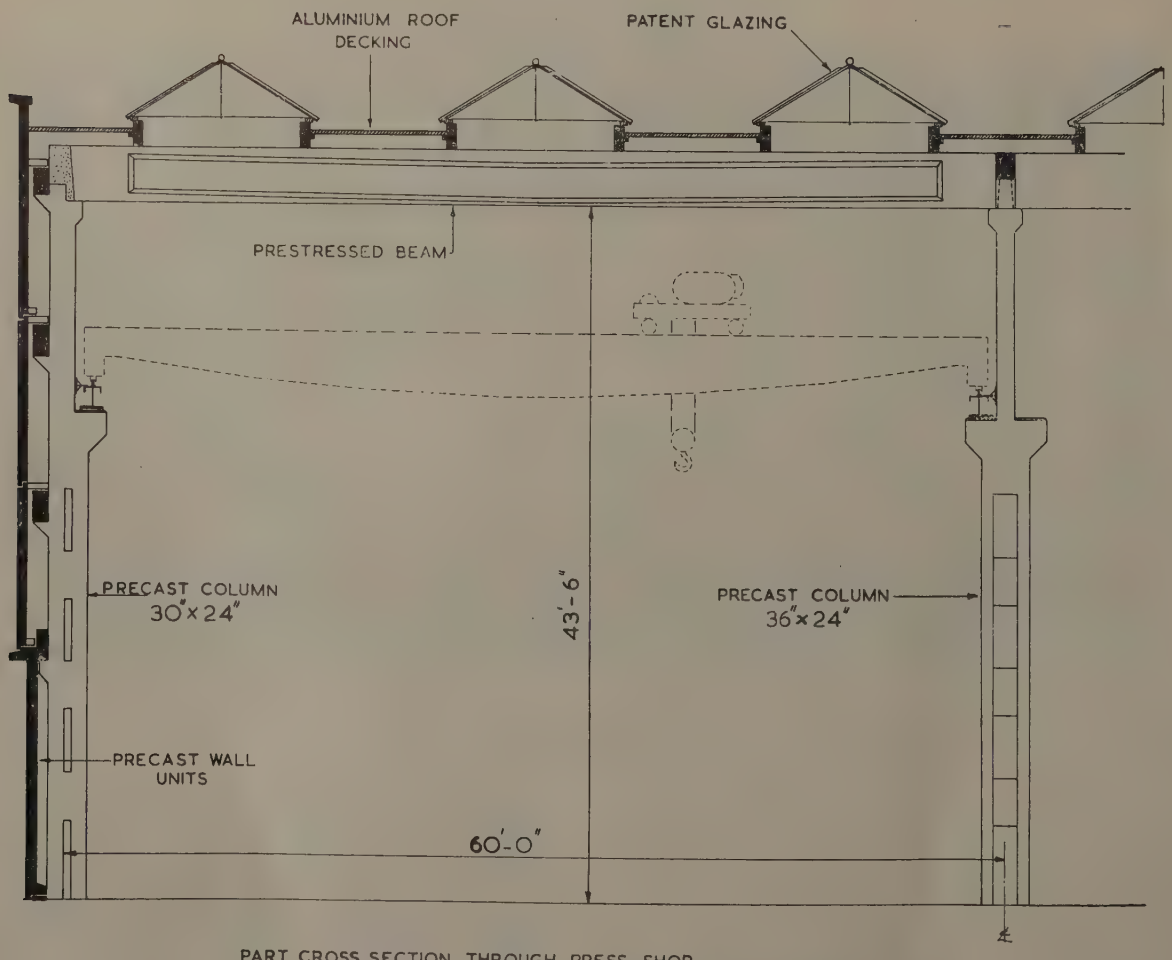


Fig. 4.—Section through the Assembly Shop



PART CROSS SECTION THROUGH PRESS SHOP

Fig. 5.—Section through the Press Shop

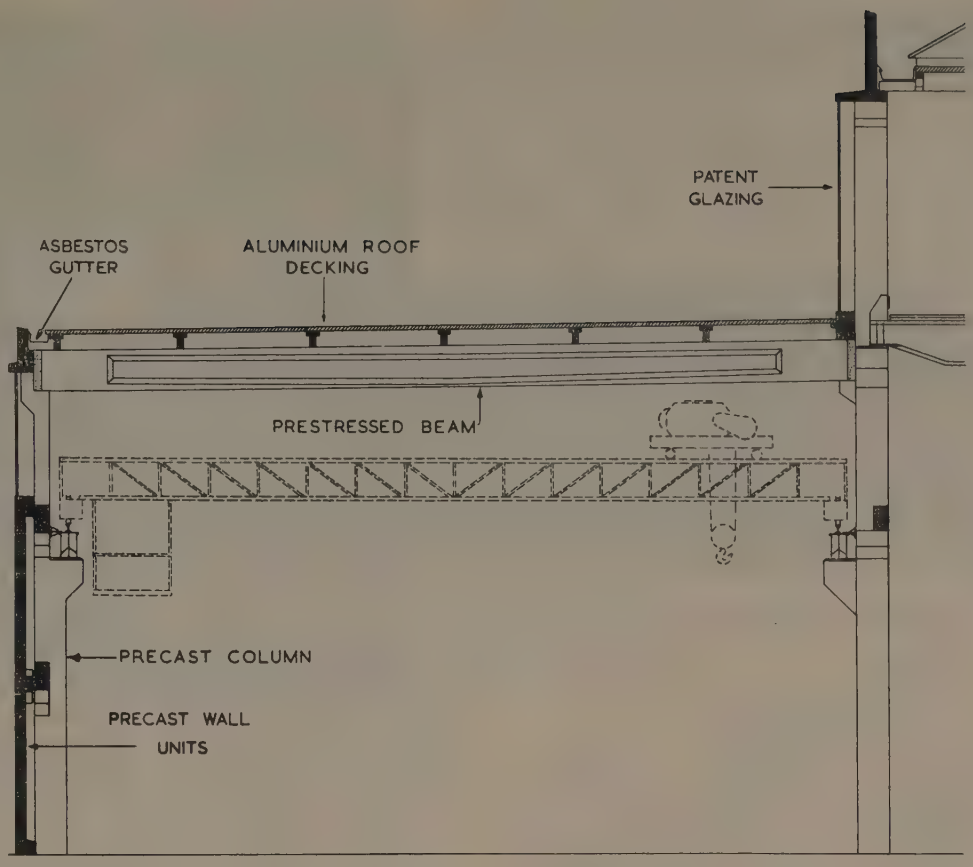


Fig. 6.—Section through the Steel Store



Fig. 7.—View of the completed structure

Here the Authors would like to place on record their appreciation of the fact that with the exception of the basement, modifications by the Pressed Steel Co. Ltd. to sketch plans already approved were negligible. This allowed design work to proceed smoothly and forward site planning to remain fully effective.

Reinforced Concrete was in accordance with C.P. 114 (1948) as amended February 1949, and Highworth Rural District Council Building Regulations.

Fully bonded prestressed concrete beams were designed for a working stress of 2,500 p.s.i. in the concrete and 74 tons p.s.i. in the steel.

Wind effects were taken in accordance with C.P. 3 Chapter V 1952 Loading ; basic exposure B.

Crane surges were as specified in B.S.S. 449 1948, amended July 1949.



Fig. 8.—General View of the Assembly Shop under construction, with Press Shop Columns in the foreground

Construction Details

(a) *Main Structure*

The north light area (Figs. 1, 4 and 8) accommodates the Assembly Shop which is divided by columns into bays of 30 ft. by 25 ft.

The roof has continuous patent glazing forming the North Lights with 12 ft. 6 in. long opening dormers every 100 ft. The south slopes are clad with corrugated reinforced asbestos sheeting lined internally with insulation board. This cladding is carried on purlins at 5 ft. 3 in. centres spanning 25 ft., of angle section $11\frac{1}{2}$ in. by $11\frac{1}{2}$ in. by 3 in., stiffened at intervals with concrete diaphragms. The ends of the purlins are solid and contain $2\frac{1}{2}$ in. diameter holes recessed at the top to accommodate a nut and washer, which gives a positive connection through the medium of a screwed dowel set in the rafters. The holes are finally grouted up. (Fig. 9.)

These purlins only were made with a level soffite and showed a slight sag when incorporated in the work. While this was in no way detrimental to their efficiency it did indicate that for the sake of internal appearance it would have been better to have provided some camber in the moulds.

The purlins are carried on rafters 31 ft. long of squat 'T' section 20 in. deep and 15 in. wide, dowelled to the top of a column at one end and to a column bracket at the other. (Fig. 10.) The 15 in. by 9 in. internal columns 36 ft. long are raked back at the top to a slope of 1 in $4\frac{1}{2}$ to accommodate the north lights. The north light glazing is carried on standard section purlins at top and bottom with a shallower unit 8 in. deep intermediately. Lateral stiffness to the structure is given by insitu concrete placed round splice bars projecting from the bottom glazing units and the columns at their junction points.

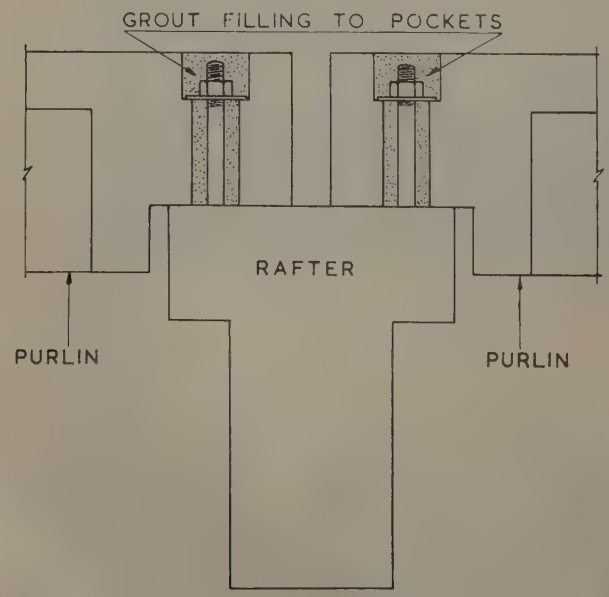


Fig. 9.—Purlin to Rafter connection—Assembly Shop

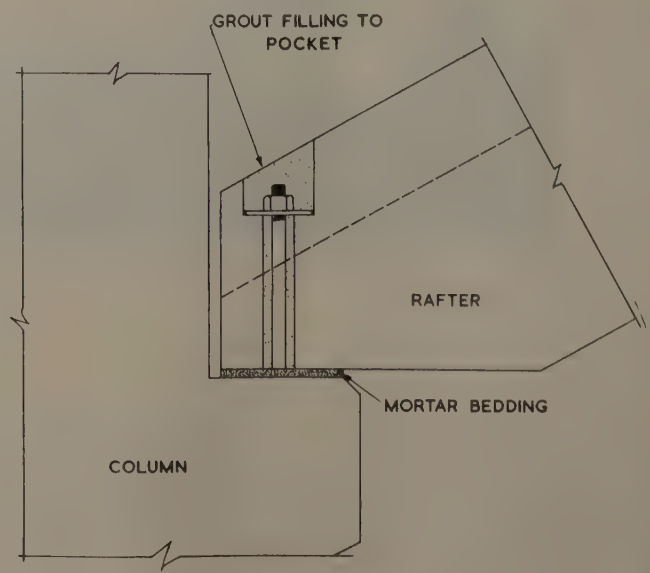


Fig. 10.—Rafter to Column connection—Assembly Shop



Fig. 11.—Assembly Shop—A precast wall section being lowered into position

Assembly Shop wall columns carry the precast cladding sections on concrete corbels. (Fig. 11.)

On the east elevation the asbestos canopy over the loading dock is carried on 8 in. by 8 in. by 3 in. angle section precast concrete and tubular steel purlins (Fig. 12) bearing on precast units at 15 ft. centres with 24 ft. long cantilevers which can flex independently of the main wall columns and cladding. At one stage of the work consideration was given to stressing together the cantilever and vertical portions of these units, but since they were to be made on site it was decided that no particular handling difficulties would be encountered and the units were cast monolithic.

Elevated toilet blocks are carried independently thus allowing all north light columns to remain standard.

Rain water is conducted away by means of asbestos gutters slung between the purlins on adjustable steel supports except on the north elevation where precast concrete guttering units form an architectural feature.

The area of the Press Shop (Figs. 1 and 5) is divided by precast columns into bays of 60 ft. by 25 ft. It is separated from the Assembly Shop by an expansion joint formed by twin columns.

The roofing material is aluminium decking, 50 per cent of the area being in patent glazing, carried on 20 in. by 8 in. precast concrete purlins at 10 ft. centres dowelled to the main roof beams.

The main roof beams of 60 ft. span and 42 in. by 12 in. 'I' section are located to give 40 ft. clear head room above the floor and are in fully bonded pre stressed concrete. (Fig. 5.)

Stiffening transverse to these beams is by means of 15 in. wide and 21 in. deep precast members dropped to 3 ft. 6 in. deep at the column head, the joint between the four beams and the column being formed through the projecting steel bonding into a cast insitu slot. (Fig. 13.)

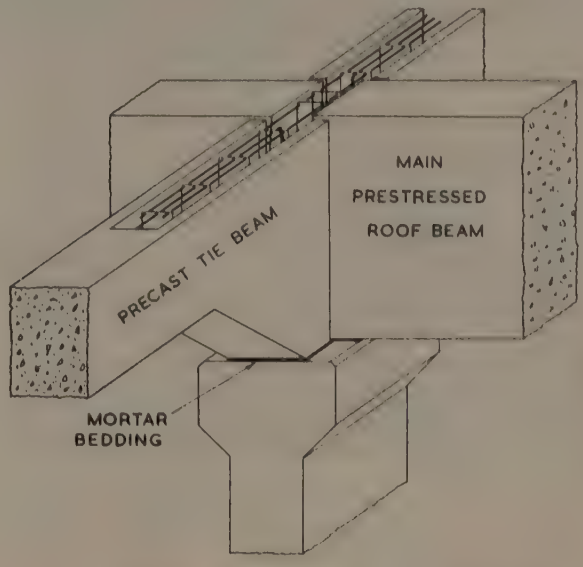


Fig. 13.—Internal column and beam connection at roof level—Press Shop



Fig. 12.—Assembly Shop—Cantilever units and purlins over the loading dock



Fig. 14.—Press Shop and Steel Store under construction

The columns which carry these beams also carry the steel crane girders for the 30 tons capacity overhead cranes which serve each 60 ft. span of the Shop. Generally they are 51 ft. long in twin 24 in. by 9 in. sections separated by diaphragms up to 31 ft. above ground level, where they are corbelled out to receive the crane beams. Above this a single section 24 in. by 14 in. extends to the roof.

The columns were in this instance founded on bored piles, since normal foundations would have been of such depth that timbering throughout would have been required, and of such area that the positioning of the larger presses would have been restricted. Further considerations showed that piling would also give a faster rate of construction.

The Steel Store (Figs. 1 and 6) adjoining and open to the Press Shop has a head room of 31 ft. 6 in. and is of 50 ft. single span, the roof being carried on fully bonded prestressed concrete beams between external columns and the adjacent line of Press Shop columns. (Fig. 14.)

(*b*) *Basement*

Hydraulic presses of various types weighing up to 170 tons each were to be installed in the Press Shop and used for pressing steel sheets for motor car body parts and work of a similar nature.

In the early stages of the contract it had been intended that the press foundations should incorporate



Fig. 15.—Press Shop Basement—exposed piles and caps

reinforced concrete pits of varying depth to clear the press mechanism extending below floor level.

Columns and roof beams had been erected and roof cladding was proceeding when it was decided that a more efficient and versatile press layout could be achieved by replacing individual pits by a basement, of sufficient depth to clear the lower portions of the largest presses. This basement would give adequate space for future re-arrangement of presses, and facilitate their maintenance. A further factor influencing the decision to construct a basement was that it provided a satisfactory solution to the problem of the disposal of scrap sheet metal. The basement was extended into the Steel Store at the north-west corner to house two scrap baling machines, fed by conveyors at basement floor level running between the press lines, scrap being fed down chutes through openings in the ground floor. This arrangement obviates the necessity for conveying scrap across the Press Shop floor to a scrap baling area.

Obviously it was necessary to plan the excavation and construction of the basement to allow work already in hand on the superstructure to proceed unhindered. The excavation depth of 15 ft. was such that the pile caps and a 5 ft. 6 in. length of pile were exposed. (Fig. 15.)

It was decided to isolate the whole of the basement from the main structure and this was effected by filling with concrete the exposed portion of the piles to the plan size of the pile caps and inserting a rubber water stop across the free joint between the concrete filling and the surrounding basement slab (Fig. 16). This not only allowed differential settlement to take place freely between the two structures, but prevented the direct transmission of any vibration set up by the presses, to the main structure.

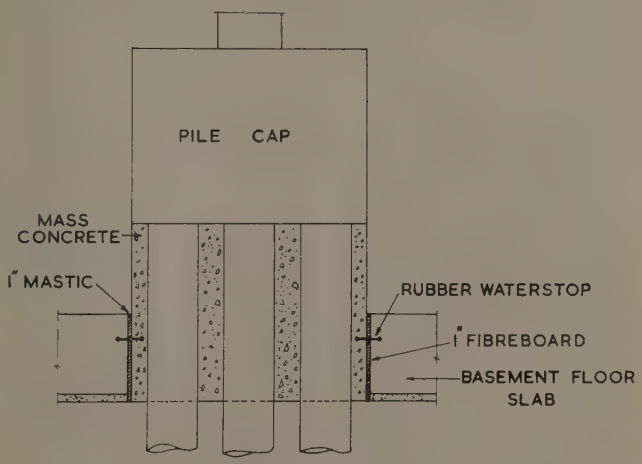


Fig. 16.—Section through a typical pile cap

Due to the heavy superimposed loads the 2 ft. 6 in. thick basement raft slab had to be designed to withstand a maximum upthrust of 2,600 lb./sq. ft. The east and west retaining walls which are 2ft. 6 in. thick are designed as propped cantilevers resisting pressure due to surcharges of $1\frac{1}{2}$ and $2\frac{1}{2}$ ton/sq. ft. respectively in addition to normal earth pressure. North and south retaining walls are designed as pure cantilevers but for a surcharge of $\frac{1}{2}$ ton/sq. ft. only.

The ground floor over the basement area consists of insitu concrete strips 12 ft. 6 in. wide of normal slab and beam construction running east-west between press lines, acting as props to abutting retaining walls (Fig. 17), the remainder of the floor being formed with precast concrete slabs. The whole of the suspended floor is designed to carry a super load of 1 ton/sq. ft. and is finished with 4 in. thick wood blocks. The concrete surface was treated with silicate of soda to give protection from any process oil which might penetrate the wood block finish.

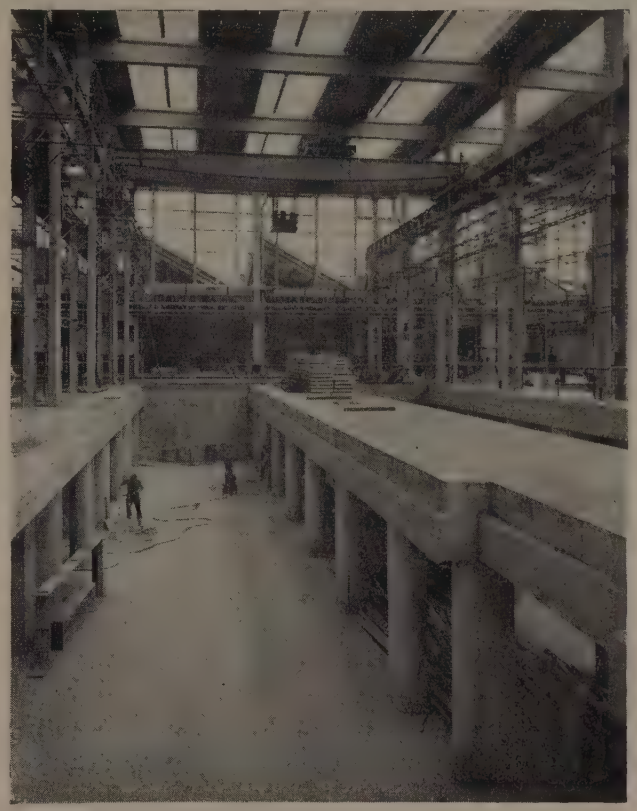


Fig. 17.—Press Shop Basement—Cast in situ strips between press lines

The space between the suspended floor and the presses is covered with removable hard wood panels, below which scrap chutes can be arranged in any position. The suspended floor over the scrap baler area is in structural steel.

All the large presses are supported on insitu reinforced concrete piers built up from basement floor level, smaller presses being carried on precast floor units.

(c) *Precast Wall Units*

A large proportion of the precast reinforced concrete wall cladding was manufactured on site, the process to form the exposed finish being developed in close collaboration with Mr. J. G. Wilson, F.R.I.B.A., of the Cement and Concrete Association.

The external surface of many of these units had an exposed aggregate finish and the units were formed face downwards. The moulds were in timber, the soffite being backed by a cradle of steel joists, and surfaced with 5-ply timber. For an exposed aggregate finish sand was laid on the 5-ply followed by a layer of aggregate of $1\frac{1}{2}$ in. maximum size, spread by hand, care being taken that no large spaces were left between individual stones. The stones were then covered by a 1 in. thick layer of $2\frac{1}{2}$:1 sand/cement mortar followed

by the placing of the reinforcement. The concrete backing was then placed and consolidated by hand. Vibration could not have been used as this would have displaced the hand packed aggregate and allowed the backing to penetrate to the surface.

For precast panels requiring a sand/cement finish the soffite was covered with a layer of latex rubber, attached with a rubber based adhesive and coated with a vegetable mould oil. A layer of sand and cement prepared for the particular surface effect required was then laid, followed by the placing of the reinforcement and concrete backing as before.

The mould in its steel cradle was turned into a vertical position between one and two days after casting, and in the case of the exposed aggregate finish, the excess sand removed by hosing and brushing. External surfaces were given a final cleaning treatment when in position.

Wall panels were provided with cast-in screwed sockets on the internal face to take lifting tackle, and to enable the panels to be clamped into position at columns, prior to grouting.

(d) *Floors*

The reinforced concrete floor of the Assembly Shop is laid on hard filling and is 6 in. thick incorporating a 2 in. granolithic topping. It is subject to very heavy trucking and extra care had therefore to be taken as regards proper consolidation of the concrete and the high quality of the edges of all joints in order to minimise flaking.

The floor was laid in widths of 15 ft., every other construction joint being eventually cut to form a contraction joint. Contraction joints at right angles to these were generally between 40 ft. and 50 ft. apart. Fabric reinforcement did not pass through contraction joints, which were dowelled, half of the dowel being treated with bitumastic paint. Dowels through construction joints were fully bonded.

Expansion joints were at about 125 ft. centres. Owing to the flaking that invariably occurs under heavy trucking conditions at expansion joints, which are by their nature relatively wide, the Authors favour their elimination wherever practicable, but would always advocate the use of compressible strips against walls and columns.

The lower 4 in. of the structural floor was consolidated by means of a compactor with a pneumatic walking mechanism of the type shown on Plate 8 of the Road Research Report for 1955, and demonstrated at their Open Day. This compactor operation was followed by the placing of the reinforcement and the 2 in. granolithic topping which was consolidated by means of a metal shod vibrating screed. The surface was finally finished with a power float with adjustable rotating blades.

In order to give sound edges to contraction joints these were cut with a mobile circular saw, the slot being filled with a mastic strip. Generally it was found that a diamond blade was the most efficient, cutting a $\frac{1}{4}$ in. wide slot $1\frac{1}{2}$ in. deep at a rate of 3 ft. per minute in concrete 7 days old. This rate of cut was found to be about the same for concrete up to three weeks old. A diamond blade, however, was found to be insufficiently wide to properly trim the edges of construction joints which were to become contraction joints, and for these a carborundum blade was used, giving a $\frac{3}{8}$ in. width of slot. This blade cut to a depth of $1\frac{1}{2}$ in. at $1\frac{1}{2}$ ft. per minute in seven days old concrete, but when joints three weeks old were attempted a speed of only 3 in. per minute could be obtained.

The area of reinforced concrete floor laid on hard-filling in the Press Shop is 12 in. thick, reinforced in two layers and surfaced with 4 in. thick wood blocks. It is 44 ft. in width and broken by a sunken rail track. It was laid in widths of not more than 15 ft., the reinforcement passing through construction joints. Expansion joints divide the slab into lengths of about 120 ft. Contraction joints were not provided.

The concrete layers below the bottom reinforcement and between the bottom and top reinforcement were consolidated separately with the compactor previously described. The surface layer was consolidated with a metal shod vibrating screed, and finished with a wood float. Bitumen grouted wood blocks were eventually laid directly on this surface.

The rail track area, which is an integral part of the floor, was similarly treated except that here the overall slab thickness is $16\frac{1}{2}$ in.

The whole of the Steel Store floor which was laid on hard filling is 12 in. thick and reinforced as for the Press Shop. It is 50 ft. wide and was again laid in widths not exceeding 15 ft.

The floor will be subject to exceptionally heavy superimposed loads and severe trucking. In order to minimise differential settlement and the flaking of wide joints due to trucking, expansion joints were not provided. The floor was, however, divided into 60 ft. lengths by contraction joints, joggles being provided for the transference of load. The top of the joggle was a few inches below surface level and the joint completed by cutting a $\frac{1}{4}$ in. wide slot on the joint line. Construction joints were formed at right angles to the contraction joints in a similar manner, except that reinforcement was continuous through them and the cut was omitted. The floor was placed in a similar manner to the Press Shop, but since there would not be a wood block finish the top surface was finished with a power float.

(e) *Erection Data*

The approximate total weight of precast units was as follows :

Assembly Shop, Structure	tons	4340
Assembly Shop, Wall Panels	tons	1030
Press Shop and Steel Store, Structure	tons	4210
Press Shop and Steel Store, Wall Panels	tons	1180
Precast floor units to Press Shop ..	tons	4000
Ancillary Buildings, Structure ..	tons	1100
Ancillary Buildings, Wall Panels ..	tons	190
Total	tons	16050

These units were erected over a period of about fourteen months.

The following items of equipment were used for erection, planning being so arranged that individual machines remained on site, only for the minimum period necessary :

One crawler mounted crane with a 90 ft. jib for loads between 12 and 17 tons for the Press Shop area.

One crawler mounted crane also with a 90 ft. jib to handle loads between 5 and 14 tons for the Ancillary Buildings, the outer sections of the Assembly Shop and Steel Store, and the cantilevered columns to the loading dock.

Two ¾ yd. crawler mounted excavators with 50 ft. jibs to handle any loads up to 5 tons, particularly precast wall cladding, the units for which were between 2 and 4½ tons.

One 6-ton crawler mounted crane to assist with the erection of the wall units.

Concrete Plant

Prior to the advent of the Press Shop Basement the insitu concrete was for the most part small in quantity and spread over a considerable area ; 14/10 mixers were used, distribution being by ¾ ton dumpers.

The Press Shop basement contained about 12,000 cu. yds. of concrete, and to cope with this increase a central batching plant, consisting of a 19 cu. ft. grab loader and overhead bins feeding two electrically driven 21/14 mixers, was installed. Concrete from this plant was distributed by 12 cu. ft. dumpers or monorail 10 cu. ft. skips, depending on the point of deposit. Where the dumpers could conveniently approach the placing point their use was found to be preferable, but for the insitu slab over the basement, monorail skips were more efficient. The output averaged 750 cu. yds. per week.

Contract Organisation

The Pressed Steel Co. were represented technically by their Works Engineer and his staff. The various activities of the Main Contractor, and the sub-contractors, were controlled by a Project Manager, who maintained close liaison with head office design staff through his planing engineer.

The work was sub-divided, within the organization of the contractor, into a structural section for foundations and factory buildings, a civil engineering section for oversite excavation, roads, rails and sewers, etc. and a section for the installation of heating, electrical and mechanical services. Various sub-contractors were engaged on general trades work.

The average labour strength on site for all sections was 240 of which 23 per cent were tradesmen. This does not include operatives employed off site in the manufacture of precast units. Skilled labour was extremely difficult to find in the area in view of the extensive industrial and housing expansions already taking place. The bulk of the labour force was obtained from neighbouring districts, coaches being used to transport men from twenty miles distant.

Weekly liaison meetings under the control of the Project Manager or the Planning Engineer were held between the engineers in charge of each sub-section, each of these again having weekly foremen's meetings at which the main programme for the following week was outlined, detailed programmes for each sub-section being given to the individual foremen concerned.

Sub-contractors' work was controlled by the Planning Engineer who held weekly meetings with the sub-contractors, and carried out supervision through his liaison foremen.

Arrangements for the manufacture of precast concrete, the delivery sequence, and inspection both at the factory and site were, together with quality control of insitu concrete, full-time tasks for engineers.

The first section of 100,000 sq. ft. of Assembly Shop, with services linked to a temporary supply, was completed eight months after the starting date.

The remaining portion of the initial development was effectively complete after a further eight months.

Notes on Civil Engineering Works

The main civil engineering works consisted of some 140,000 cu. yds. of excavation and levelling, most of which was spread and consolidated, on the site north of the initial development area.

Works roads 40 ft. wide amounted to 3,600 ft. in length, and rail sidings to 2,300 ft.

In order to make up the floor level of Building 'A' and various low areas, 45,000 cu. yds. of hard filling were imported, spread and consolidated.

The most interesting feature of the civil engineering work was the surface water drainage system. Pipes which varied in internal diameter from 9 in. to 72 in. were mostly in spun concrete with flexible joints, and in all totalled 12,000 ft. run. The surface water outfall which was in tunnel extended in a southerly direction from the collecting manhole, via a Silt Chamber, under the main London to Bristol railway line and the Oxford road, to a position where it changed to an open channel as far as the River Cole.

The total length of tunnel was 880 ft., the linings being formed in precast concrete rings 96 in. internal diameter under the railway and 84 in. elsewhere, the whole tunnel being lined again with 72 in. diameter pipes.

The pipes were lowered into the silt chamber and hauled along the tunnel on greased timber skids by means of a small air winch. Grouting of the tunnel was carried out through preformed holes in the linings.

Notes on Services

The services designed and supplied by Messrs. Engineering Service Installations Ltd. were for steam, hot and cold water, welders cooling water, Town and Acetylene gas, electric lighting and small power, sanitation and drainage.

At the design stage close liaison was maintained with the structural design office, with the result that adequate prepared holes were incorporated in precast members, for the attachment of service supports.

Steam is generated through three oil-fired boilers each of capacity 20,000 lb. per hr. at 100 p.s.i. and conveyed by external distributing mains to the various buildings which are warmed by unit heaters to 65°F.

Hot water is supplied through individual calorifiers adjacent to ablutions, heated by electric immersion heaters during the summer.

Cooling water is supplied to the welding transformers by two centrifugal pumps from an underground storage supply.

The town gas distribution pipework is based on the ring main ladder system ensuring equal pressures throughout the area served. Acetylene gas is generated on site and distributed in the same manner.

The electrical installation includes 1665 light points and 350 power points, supplied through 133,000 lineal yards of cables and conduits. The lighting system in the assembly area is designed to provide illumination of 12 ft. candles when using 300 watt lamps or 25 ft. candles for 500, the lights being wired in sub-circuits of 4. The fittings in the Press Shop are suspended at 40 ft. above floor level, 1000 watt lamps giving an illumination of 10 ft. candles. There is a pilot lighting system in all areas for night inspection. Thermostatically controlled unit heater fans are wired in circuits of five. Throughout the installations extensive use has been made of purpose built sheet steel boxes

formed to go round columns, to replace normal conduit methods, thus effecting economy in labour and material.

Conclusions and Acknowledgments

The Authors feel that the maximum use of precast normal reinforced and prestressed concrete elements and the use on a large scale of precast concrete wall panels with an exposed aggregate finish have been justified by the results obtained. The maximum weight and length of precast units used was 17 tons and 53 ft. respectively, but the Authors have subsequently been concerned in the use of units of similar weight and 71 ft. long. They feel that the precasting methods employed have a considerable future in industrial work and can foresee no ultimate limit as regards size and weight. The total approximate cost of the work described, including ancillary buildings and services, was £1½ million.

The Authors wish to thank the Pressed Steel Co. Ltd. for permission to present the information given in the paper and for their help in its preparation.

The Clients' Works Engineer was Mr. Cyril Everett.

The Main Contractor appointed Mr. Bertram Carter, F.R.I.B.A., as Consultant Architect.

The structural design of the Ancillary Buildings, only briefly mentioned in the paper, was carried out in collaboration with Mr. H. G. Cousins, B.Sc., M.I.Struct.E., M.I.C.E., Mr. R. A. Sefton Jenkins, B.Sc., A.M.I.Struct.E., A.M.I.C.E., and Messrs. Twisteel Ltd.

Precast units not made on the site were supplied by Messrs. David Chaston Ltd., Concrete Development Co. Ltd., Concrete Ltd., Cowley Concrete Co. Ltd., and Qualcrete Ltd.

Mr. J. M. L. Uren, B.Sc., A.M.I.Struct.E., A.M.I.C.E., was the Contractor's Project Manager on Site.

The Authors also wish to thank all those who assisted in the collection of information and the preparation of the paper.

Book Reviews

Architectural Construction : The Choice of Structural Design, 2nd Edition, by Theodore Crane. (New York : John Wiley, 1956 ; London : Chapman & Hall). 9½ in. × 6¼ in. 433 plus ix pp, 80/-.

This book deals with the problem of making an appropriate choice for the structural portions of a building, as governed by the geographical location, site conditions, type of occupancy, equipment and architectural design. It presents a procedure for determining the type of building frame, foundation, floor, roof and wall construction most suitable to meet the requirements of any particular structure.

Since the publication of the first edition, economic conditions have caused important changes, and this second edition offers a comprehensive view of the more useful types of construction for, and the newest features of, building design available in the United States today. It describes contemporary fireproofing details for steel assemblies and other similar practical considerations, and deals with designs for large buildings, such as coliseums and aircraft hangars.

Although primarily written for American architects, much of this book will be of interest to architects and structural engineers in this country.

The Weldability of High-Tensile Structural Steels, by C. L. M. Cottrell, K. Winterton, and B. J. Bradstreet. (London : British Welding Research Association, 1956.) 10½ in. × 8½ in. 79 pp. plus 40 figs., 20/-.
Post free.

During the period of June 1948—May 1954 the British Welding Research Association, on behalf of the Ministry of Supply, carried out a considerable research programme on the metal-arc welding of high-tensile structural steels. The above is a report on this work.

The work described includes examination of existing weldability tests, the concept of critical cooling rate and the development of the controlled thermal severity (C.T.S.) test, and the correlation between weldability and end-of-transformation temperature as determined by continuous dilatation tests.

The report is divided into four parts, the first two dealing with the development and testing of the special steels, and the second two with the mechanism of hard-zone cracking, the assessment of weldability using physical and mechanical testing schedules and the influence of hard-zone cracking on fatigue life of fillet-welds.

Arc-Welded Machinery Construction in Mild Steel, by A. G. Thompson. (London : British Welding Research Association, 1956.) 9¾ in. × 7¼ in. 36 pp., 6/-.

This booklet deals with the design of arc-welded machinery construction, and in its production emphasis has been laid on providing the facts clearly and concisely.

Details are given concerning the welds used and the static and fatigue stresses imposed upon them, the elements of machines, beams, and stiffened flat plates. These are supplemented with diagrams and sketches. Factors which reduce cost and the specification of work for manufacture are dealt with directly and concisely. A comprehensive bibliography of over 50 references is given for further reading and study.

The Use of Gunite as a Structural Material*

Discussion on the Paper by Mr. T. Whitley Moran, B.A., B.A.I., M.I.C.E. (Member)

The President introduced Mr. MORAN, who then presented his paper, which he illustrated by many photographs and drawings of repair work on reinforced concrete structures.

Discussion

The PRESIDENT proposed a very hearty vote of thanks to Mr. Moran, not only for his extremely interesting paper but also for the admirable way in which he had presented it.

(The vote of thanks was warmly accorded.)

Continuing, the President said that he had been very surprised to learn how short the average life of reinforced concrete structures was found to be in the experience of Mr. Moran. The paper was one of great interest to all structural engineers and it gave not only much information on structures which had been repaired by Gunite, but also gave recommendations for prolonging the useful life of reinforced concrete structures.

Some of the photographs which had been shown of reinforced concrete structures, which had deteriorated seriously in a relatively short life, he confessed, had shocked him. But this shock and dismay were countered to a certain extent by relief in finding that some of those structures were still standing and presumably still carrying their load. Examples were shown of beams which had lost all their stirrups, the beams acting then as arches with tie rods. In other words, although the destructive effects of nature had caused so much deterioration that the beam could not work in the way it was designed to do, nature had also provided some other way in which the member could still continue to function and carry its load. But for this fortunate behaviour of nature he felt we should have had many more disasters than we had experienced to date.

The question of durability (as Mr. Moran had emphasised) was a matter to which insufficient consideration was often given in the design stage. We devoted great attention to ensuring that our designs were structurally adequate and also that the structures were built strictly in accordance with our drawings; but did we always give enough thought to durability? The answer had been given by Mr. Moran. Many of us had not done so in the past, but it did appear that in the great majority of reinforced concrete structures in which serious deterioration had occurred the cause had been inadequate cover for the reinforcement. This was a matter which could and should receive the most careful attention and consideration of all concerned with the design or the construction of reinforced concrete structures.

Finally, he said Dr. Hamilton had made a very thorough study indeed of the durability of concrete structures, and everyone concerned was awaiting with great interest the publication of the Report incorporating the fruits of his labours.

Dr. S. B. HAMILTON, O.B.E. (Immediate Past President) expressed his very great pleasure in taking part in the discussion of the paper, particularly because he had received generous assistance in his work from Mr. Moran, to whom he was very grateful. He also expressed his thanks for the way in which Mr. Moran had mentioned his work and the report on it, which latter, he was sorry to say was still in the press although his work on it was finished some months ago.

When he had started on the work it was a joint effort between the Building Research Station and the Cement and Concrete Association. Visits were paid by Mr. Bray of the Cement and Concrete Association and himself to a large number of buildings where serious deterioration had taken place, and to some where it had not; they were examined very carefully and it was concluded that, although many things could happen to reinforced concrete buildings, the troubles which in fact were found in nearly all cases were caused, as the President had reminded the meeting, by there being insufficient covering of concrete. In some cases the situation was made worse by such cover as had been provided not being very good. If there were room for a concrete covering of only $\frac{1}{2}$ in. and the aggregate used was $\frac{3}{4}$ in. stone the concrete which did seep between the reinforcement and the shuttering was not a very good protection against corrosion.

It was felt that it would not be helpful merely to tell people how things went wrong—many knew that already; they ought to indicate how the trouble could be put right. There was little literature on repair work as compared with that on methods of design and construction, but one of the most useful papers they had found was that by Mr. Moran[1] in 1938 on the use of gunite. At that time gunite had in this country something less than twenty years' past history, including the period during which a good deal of the work was somewhat experimental; so that the conclusions that Mr. Moran had formed in 1938 were perhaps somewhat tentative, although he was not a man who was given to tentative opinions, and he had shown by his present paper that the last twenty years of experience had almost entirely confirmed the opinions he had formed in 1938. He was able to speak with great experience of that branch of work, in which he was one of our leading specialists. The meeting had been privileged to hear something from a man who was not afraid to show the results of damage and of repair work. The speaker had enjoyed Mr. Moran's company on visits to several of the sites described in the paper, and could add his personal gratitude to that of the Institution for a most interesting communication.

Mr. W. J. YOUNG, as one of Mr. Moran's competitors, said the conclusions given in the paper agreed entirely with his firm's experience in that field.

He took the opportunity to compliment Mr. Moran on the immense amount of analytical work and historical information he had put into the paper, for it was really most enlightening to find some definite written material on that aspect of the subject. There was a good deal of hearsay and there was information in other papers, but Mr. Moran had done a great work in making that material available.

**Paper read before the Institution of Structural Engineers at 11, Upper Belgrave Street, London, S.W.1, on the 9th February, 1956. Mr. Stanley Vaughan, B.Sc., M.I.C.E., M.I.Struct.E. (President) in the Chair. Published in the* STRUCTURAL ENGINEER, *Vol.* xxxiv, *No.* 2, *pp.* 37-66. *Feb.*, 1956.

Mr. Young did not presume to comment on the conclusions given ; he could only endorse them.

Mr. C. R. HART, another of Mr. Moran's competitors and a colleague of Mr. Young, voiced his own thanks for what he considered to be a very good paper indeed and said it was pleasing to find it followed out his own firm's views.

He went on to stress the point made by Mr. Moran that it was most essential to carry the " Gunite " over the entire structure, wherever possible, rather than to deal with odd patches here and there, for it was often found that further rusting occurred at a later period beyond the repaired sections. He also considered that it was essential to use reinforcement in the " Gunite " and referred to the failure on a beam illustrated on which unreinforced " Gunite " had been used.

Lt.-Colonel G. W. KIRKLAND, M.B.E. (Hon. Editor) said he felt a glow of warmth towards Mr. Moran on reading the paper. He was one of the few authors who had used the term " contraction joints " ; but he had excused himself very cleverly because he had his consulting engineer present.

Having said how much he had enjoyed the paper, Lt.-Col. Kirkland raised one or two points on which he asked for Mr. Moran's comments and opinion. The first was that of contraction. He had been a strong advocate of gunite, he said, for various structural purposes, not only for repairs, but also for construction, and had been rather concerned on occasions when authorities had deplored the use of gunite because of the high contraction rate. Where, he asked, did people get this idea, and what was Mr. Moran's experience ?

Secondly, all the illustrations of gunite on existing fabrics appeared to have been on vertical work, other than where additional cover was desirable. If we had a horizontal slab which had worn badly or which had been carried out in poor concrete, could we obtain the necessary adhesion ? Would it be possible to have a feather-edge finish ?

Another point concerned foundations. Our predecessors had erected some very fine buildings, particularly the public ones, and examples had been quoted of work which had lasted for generations. But some of those responsible, he regretted to say, were cheese-paring, not only in the provision of adequate cover, but also in respect of the foundations. He asked if Mr. Moran had experience of foundations having settled due to the considerably increased deadweight they had to carry after treatment with gunite.

Finally, he said that Mr. Moran earned his living by remedying defective structures, and thanks were due to him for his public spiritedness and his almost professional approach, in advising engineers how to provide structures in future so that he would no longer be able to earn any money by repairing them !

Mr. MORAN, after thanking the President, Lt.-Col. Kirkland, and previous speakers for their kind remarks, went on to say that the contraction rate in gunite was high because it was a rich mix, in most cases richer than the concrete to which it was applied. The reinforcement used in gunite was normally there for the purpose of controlling the cracking ; it divided the shrinkage up into a large number of fine cracks which did not show on the surface, and there was no detriment. In some cases the reinforcement is used for quite a different purpose, that is, to add some margin of strength or to replace loss through corrosion.

He had never thickened floor slabs by putting gunite on the top surface, and he would not be too happy about the adhesion in that case. It was much easier to secure adhesion when placing gunite on a vertical, sloping or overhead surface ; if the adhesion on a flat surface gave way and horizontal shear occurred the repair would be ineffective.

The possibility of settlement of foundations due to the extra weight of a gunite casing was one which had to be considered, though he could not recall a failure from this cause. He could recollect at least two cases in which he had recommended against a repair because there were signs that the structures were already settling under the existing load, and the extra load of a gunite encasement might have been critical.

With regard to contraction and expansion joints, he had experienced a good deal of trouble due to expansion in long structures such as dams. Recently his partner had read a paper in Liverpool concerning some dams in which much of the guniting was carried out in the autumn and winter. After a series of hot summers and cold winters it was found that the bond had failed locally and some of the gunite had lifted off the face. The gunite applied in low temperatures had expanded in the summer, and insufficient provision had been made for relief of the stresses. Where cold weather guniting was done on long structures, an adequate number of expansion joints was needed, and conversely, contraction joints should be provided in hot weather gunite.

Mr. A. JACKSON first congratulated Mr. Moran on a very useful paper on a subject which it was very difficult to put over.

On the question of adhesion, he said his Company had made some tests on the Mersey Tunnel to prove the adhesion of gunite to ordinary concrete. There was no doubt that when repair work was done by hand the adhesion was not 15 per cent of that achieved by guniting.

Whilst he agreed with Lt.-Col. Kirkland that those concerned with repair work were probably cutting their own throats from the point of view of earning money, he believed that one of the greatest faults in reinforced concrete was not the design, but the human element, the man who put in the concrete. So many cases came to mind where a floor slab or a decking had failed because the contractor had done the work too quickly and had used sloppy concrete.

Mr. MORAN commented that perhaps he had not given sufficient stress to the question of adhesion in the paper. The fact of the matter was that we could not use gunite for that sort of repair work unless we could ensure a high degree of adhesion. That was the point that Mr. Jackson was making.

Mr. JACKSON agreed.

Mr. C. B. BROWN (Member) who also referred to the question of adhesion, said that the grade of the concrete on which gunite was placed must be up to a certain standard in order to attain good results.

A year or two ago he had been called in to advise on the deterioration of a reinforced concrete warehouse. This building was found to be in a shocking condition, owing to many causes. Firstly, the design was bad ; secondly, there was too little cover on the reinforcement, and thirdly the floors had been very much overloaded. The main cause of the trouble, however, was definitely bad concrete. When samples were taken of the concrete, it was found to be so bad that one could almost pick it out with the fingers. At the time he had sought advice from Mr. Moran, who, in his usual frank and public-spirited manner had recommended that gunite should not be used in this particular case, because there seemed to be no sound material on which to get it to stick. Eventually the whole of the building had

virtually to be reconstructed, owing to the fact that any attempt to cut away defective concrete merely resulted in there being nothing left except rather rusty reinforcement.

Mr. Brown therefore asked Mr. Moran whether he could say something more about the standard of concrete on which gunite should satisfactorily be placed.

He added his personal thanks and appreciation for a most interesting paper.

Mr. MORAN said Mr. Brown had raised a very important matter. In the case referred to, the concrete was of very low quality. The outside walls of this warehouse had been refaced with gunite some years earlier but the concrete was so bad that there was every prospect of the new face separating from the old concrete. He had therefore used self-tightening rawlbolts, placed at very frequent intervals over the surface of the building so as to provide anchorage.

In repairing concrete he had frequently seen cases where the tensile strength of the concrete was less than the bond strength of the gunite. In the adhesion tests in the Mersey Tunnel, to which Mr. Jackson had referred, the gunite came away from the concrete not by failure of the bond but by failure of the concrete immediately behind the bond plane. The gunite lifted off a thickness of $\frac{1}{2}$ in. or more of concrete.

Dr. P. W. ABELES (Member) said he had understood Mr. Moran to say that, although gunite was a very dense concrete, a $\frac{1}{2}$ in. cover was insufficient. Of course, a cover even as much as 2 in. would be insufficient if the concrete were porous ; but he referred to spun concrete masts in the European continent having only $\frac{1}{2}$ in. net cover which had withstood satisfactorily the worst industrial conditions and said he was surprised that much more than that was needed when using a similar dense concrete such as gunite.

Secondly, in connection with the remarks of the President regarding the strength of reinforced concrete, Dr. Abeles said he had seen some tests in the Research Department of the American Association of Railroad. A railway bridge which was forty-five years old had to be taken down because the railway company was afraid that it would collapse. Since the concrete had spalled off and the lower part was free, the reinforcement had corroded. This opportunity of replacement was taken to test the bridge to destruction. The permissible steel stress at the time the bridge was built was only 14,000 lb. per sq. in. ; at a load corresponding to that stress the deflection was very small, and the failure load corresponded to the yield point of the steel, although there was no cover underneath the reinforcement which was partially corroded. That showed that reinforced concrete was a material which had great strength and behaved much better than was thought to be the case by those who were afraid of fine hair cracks.

Obviously, prestressing should provide a good opportunity for strengthening structures. Dr. Abeles mentioned that in 1948 he was able to strengthen a church tower in Staffordshire which was tilted to a certain extent due to mining subsidence. Some chases were cut into the structure, which had stone and brick walls ; prestressing cables were placed in the chases and tensioned against strong backs. Afterwards the chases were pressure grouted ; before prestressing, the stonework in the compression zone had been strengthened by pressure grouting. It should be possible to strengthen ordinary reinforced concrete by adding prestressing cables or wires, but it would be necessary to have openings cut across for the anchorage. From his experience of various repair works he had found that it is possible by careful work to obtain a good connection between the existing work and the new concrete.

Mr. MORAN said that the human element was important in regard to the thickness of cover. Tolerances were necessary in fixing steel, and in applying gunite, and allowance must be made for them. He agreed that the density of the concrete was important as well as the thickness of cover. Spun concrete units were factory-made, and the placing of the reinforcement and the quality of concrete were under closer control than on normal site work. He had had some disappointing experiences in regard to the quality of site concrete, and these had led to the suggestion in his paper that the physical cover should be increased.

A $\frac{1}{2}$ in. cover of gunite might be enough if everything else was 100 per cent perfect, but a steel fixer had only to leave a few wires close to the surface to enable rust to travel back to the reinforcement and perhaps spread 8 or 10 ft. along it. The same effect would be caused by the nozzle operator allowing a little rebounding sand to be trapped in the work. The thicknesses of gunite he had suggested allowed for human imperfections.

Mr. J. GUTHRIE BROWN (Vice-President) commented that as he had looked at Mr. Moran's lantern slides of deteriorated steel and concrete he was reminded of a story concerning the Duke of Wellington. The Duke, when inspecting a group of new and very raw recruits, had remarked : " I don't know what effect these men will have on the enemy, but by God they frighten me ! " Among the slides shown were some of the worst examples of design and execution he had seen for many years. He hoped Mr. Moran would lock them away when he had finished with them.

The comments made by the Author on the various dams in North Wales had interested him because he had been for many years in close touch with those dams as he had to inspect them under the Reservoirs (Safety Provisions) Act. He had seen the areas where gunite had been put on, and that material had certainly given twenty years of good service.

In his experience, for the face work of dams there was nothing so good as 18 in. or 2 ft. thickness of high quality concrete, dense and well compacted. In his opinion that was the only sure way in which to provide against the destructive effects of peaty water on concrete.

Commenting on the Author's reference to a dam in the Lake District which had been specifically designed for a gunite facing, he said that this procedure had rather surprised him. He did not say that as any criticism of gunite, but it did not seem to him to be the best way in which to tackle the problem. However, as Mr. Moran had said, time would show, and certainly he would be interested to know how it behaved.

In case it might be thought that he was rather denigrating gunite, he said that from his experience on thermal power stations there was nothing better than 2 in. of gunite applied as a lining to the coal bunkers.

Mr. MORAN agreed that an 18 in. or 24 in. layer of dense concrete facing on a new dam was the ideal solution. However, he had seen several old dams where the facing was not dense, and had been attacked by peaty water. In one case the face of an old concrete dam in the Lake District was disintegrating from this cause. It was gunited about fifteen years ago, and the gunite was unaffected. It was just beginning to dust slightly.

The new dam referred to was in the same area. The consultants had considered using a granite face, but they finally decided upon a gunite face, in view of the successful results obtained on the older dam close by. The gunite facing was much less costly. The spacing of the joints was arranged to suit the time of the year in which the guniting was done. We should not know the result for certain for twenty years.

Mr. J. R. Lowe (Associate-Member) remarked that, judging by Mr. Moran's photographs, some of the earlier prestressed structures would need repair before long. He asked if Mr. Moran had any experience of repairing prestressed concrete work, or if he had any idea on the subject.

Secondly, had Mr. Moran thought of using gunite for joints between precast units laid end-to-end and jointed and prestressed ?

Mr. Moran replied that he had never met the problem referred to in Mr. Lowe's second question, so could not comment.

He had not yet repaired a prestressed concrete structure, but thought it would be a difficult undertaking. He was not greatly surprised to read of some failures which had occurred because, despite tight specifications, the site arrangements for grouting up the cables were often defective. He took more precautions on simple operations like the grouting of old masonry bridges, than he had seen taken on site grouting in prestressed structures.

His final comment was that the repair of prestressed concrete structures in which some of the cables had failed would provide some knotty problems for the rising generation of Engineers.

The President, at the close of the meeting, said that, as he had hoped, the paper had provoked a most interesting discussion, and he believed that more speakers would have liked to have taken part. If that were so he asked that they would kindly send in written contributions ; he was sure Mr. Moran would be very glad to reply to them.

Recalling Lt.-Col. Kirkland's tribute to Mr. Moran's public spiritedness in taking steps that would put him out of work, the President said that, although he had a very high regard for Mr. Moran's public spirit, he also felt sure that he was a man of great foresight. There were, after all, perhaps some 20,000 or 30,000 structures which at the moment were deteriorating at various rates, and a large proportion of these would no doubt keep Mr. Moran very busy for the rest of his life. So that, even if by his recommendations Mr. Moran was perhaps taking the bread from his children's mouths, he was not taking it from his own !

Finally, on the President's proposal, the meeting again applauded Mr. Moran for his paper and his replies to the discussion.

Written Discussion

Brigadier A. Minnis, C.B.E. (Member) :

Gunite has not even yet begun to be appreciated at its full value ; and I was pleased to hear from Mr. Moran that the Barge Pier at Shoeburyness, repaired twenty-six years ago, a pioneer job in this country, shows very little sign of deterioration today.

When I took over, in the Autumn of 1929, as Garrison Engineer, Shoeburyness, I put forward a project for repair of the R.C. substructure of the Pier by Gunite and replacement of the timber deck by a reinforced concrete deck, incorporating heavy tramrails. All construction work at Shoeburyness at that time was done by directly employed labour, and the R.C. deck presented no difficulty ; but I had no cement guns nor labour trained in their use. The Gunite work was therefore put out to tender, and let to the Concrete Proofing Company.

It is amusing to reflect, in view of the later co-operation which resulted in a first-class job, that my early acquaintance with Mr. Moran and Mr. Jackson was mutually suspicious. It was my first job in Gunite, I had never heard of this Firm ; and I was not reassured when I first heard their charming Irish brogue, and its promise of blarney !

As for them it seemed that they held the not uncommon opinion that a Regular Officer's technical knowledge was bounded by an ability to count up to ten, and they thought that they would either have an easy run, or be irritated by that sticky insistence on the letter which is so often the refuge of the incompetent.

However, once we discovered that we shared the basic opinion (an opinion I have never had reason to change) that Gunite work is either very, very good or quite useless, we had common ground on which to base a successful partnership.

I would like to add my testimony to Mr. Moran's remarks about the causes of deterioration of R.C. structures.

(a) *Inadequate Cover*

When all consideration is given to the action of chemicals, sea water, or moorland water, or to impact of vessels moored to piers, or of rolling loads on bridge members, I am sure that the overwhelming cause of deterioration of R.C. work boils down to inadequate cover, in thickness or quality or both. The Barge Pier rail-bearers which had suffered so terribly by bursting by corroded steel had usually under an inch of cover, and often no cover at all, on the undersides of the beams. This is not meant to imply that the steel had not been carefully placed originally ; but it had been pushed out of place by over-zealous ramming of the concrete, especially the flat-steel stirrups which in places had been driven down on to the shuttering. The steel thus exposed had conducted sea spray hanging on the underside of the beams to the main reinforcement, and time had done the rest.

The relatively slight deterioration of the vertical and inclined members of the trestles was no doubt partly due to ramming being possible between steel and formwork, which was not possible in the case of the horizontal rail-bearers in the pre-vibration days when the pier was built.

The paramount importance of adequate cover was strikingly illustrated when, for some reason I have forgotten, I had occasion, when laying the R.C. deck, to cut through a rail-bearer and expose the reinforcement. It happened that in this case there was 2 in. of cover, and the bars were quite perfect.

Gunite is so dense that much less thickness of cover is needed than in the case of ordinary concrete, but even here the " human element " in the shape of trapped " rebound " and of fag-ends of tying wire left sticking out to the surface can lead to trouble. An extra thick final coat will more than pay for itself.

(b) *Wet, Dry or Workable ?*

Leading from the above comes the matter of the density of concrete with its consequences on its own imperviousness, and on the final positioning as well as life, of the steel.

" Wet " concrete is neither strong nor impervious in any case ; but the chances are that the steel will not be disturbed when the concrete is placed.

" Dry " concrete by which I mean concrete mixed with only the theoretically optimum water content, will (if it can be rammed or vibrated enough), be nearly impervious, but the odds are that by the time we have punched and shaken, we hope, every air-pocket out of it, the steel will almost certainly have been shifted. The composite material (i.e. concrete and steel) of which we are making our beam, column, slab or arch, and in which *the position of the steel is of vital importance*, will seldom be in fact what we think it to be.

I am as sure as I am that I shall probably shock our perfectionists that a workable (not wet) concrete, of 90 per cent quality which can be 100 per cent placed and compacted without shifting the steel, will give a stronger and more impervious job than the 100 per cent mix, 80 per cent compacted round more or less displaced steel, which is what is usually achieved by the dry-mix sticklers. The greatest single cause of poor quality work, in R.C. or anything else, is what we call the " human element," and the less messing about we can have by careless or incompetent workmen (and the best are not perfect) the better.

(Incidentally, do we really believe that we get, in the job, the strengths shown by our absurdly carefully filled and consolidated test cubes ?)

Mr. Moran's somewhat caustic remarks about the short life of some modern structures when compared with the ancient buildings still surviving, struck me as unfair. The ancients made very little use of tensile stress, which depends on steel, with its liability to the effects of corrosion ; and in the nature of things it cannot be expected to last centuries. But modern demands could not be met by ancient methods ; and anyway who would want most modern buildings to last beyond their strictly useful life ? Imagine a time-bedraggled steel frame or R.C. building exhibiting itself beside the attractively weathered masonry of our forefathers !

Thinking of tensile stress leads me to wonder how one would set about the repair of a corrosion-weakened prestressed structure or how decay will be detected before collapse ? The problem is not likely to concern me, but our colleagues now in their forties might be thinking about it !

Mr. MORAN welcomed Brigadier Minnis's remarks. Any suspicion on his side which may have existed when they had first met was quickly dissipated when he found that this Regular Officer had a highly competent knowledge of reinforced concrete construction, and it became a pleasure to work on a job in which both parties were co-operating to secure the best results. He entirely agreed that gunite work must be of high quality or it is worthless ; and furthermore that thin finishing coats are inadvisable and the final coat should preferably be ½ in. thick.

He could best answer Brigadier Minnis's other remarks by describing a personal experience he had had nearly 30 years ago when he was contractor's agent on the construction of a reinforced concrete bridge. The Resident Engineer was holding out for a dry mix and equally for the accurate positioning of the steel. As the result of a bet, the Resident Engineer and he worked side by side in the punning gang for a 9-hour day, and over a pot of beer that night they agreed (a) that punning required a high degree of intelligence, and if the specification was to be rigidly complied with, they would have to recruit a gang of graduate engineers to place the concrete, and (b) if every designer spent one day per month working in the construction gang the effect would be salutary.

Of course this is only one side of the picture. Reinforced concrete construction is still officially regarded as an unskilled operation, but this view is unrealistic. If a scheme could be devised for giving foremen and operatives some training in the basic elements of reinforced concrete work, it would be a great advance.

Mr. K. F. A. LINTON :

As a chemist interested in cements, my attention was drawn by Mr. Moran's references to failures of concrete in industrial situations, due to attack by acids. Clearly the nature of the cement is an important factor and in such cases the use of supersulphate (slag-sulphate) cement is finding increasing favour ; it can be used for the concrete or for gunited linings and structural repairs.

Mr. MORAN agreed that when fumes or weak chemical solutions were present, it was advisable to consider the use of a special cement. He had used super-sulphate cement and other special types of cement on various occasions with successful results. These materials differed from Portland Cement and from one another in regard to their physical properties and the curing procedure, and it was always necessary to obtain precise information on how to handle them.

Mr. S. ROSENAK :

Referring to the design aspect of the strengthening of structures by guniting, Mr. Moran says on p. 51 :

> " It is normally impossible to calculate what the distribution of stresses will be in a structure which has been strengthened following incipient failure through overstress. Where the live load cannot be removed or the members jacked up, the added reinforcement will not accept stress until deflection begins to occur in the original work. These are the considerations that give rise to the conception of ignoring normal design considerations and setting out to provide a factor of safety against collapse."

I should be glad if Mr. Moran could enlarge on his remarks. Where it appears that the reinforcement in the case of a beam, for instance, has been overstressed is the added reinforcement considered to take the full load or only a portion of the load assuming that further deflection takes place ?

It would be extremely useful to carry out loading tests on parts of structures such as beams which have been strengthened by guniting. Could Mr. Moran give details of such tests which he may have carried out in the course of his work ?

Mr. MORAN :

The assumptions relating to the added reinforcement need careful consideration in each individual case. In the circumstances stated by Mr. Rosenak, the simplest basis of calculation is to provide new steel (preferably high tensile) sufficient to take the full load, on the assumption that the new steel is stressed up to, say, 5,000 lbs. short of the yield point. In that way, the factor of safety against collapse will be increased by one. The assumptions here are that the existing beams are capable of carrying the total load, but not without overstressing : that, as the structure has not failed, there is still a factor of safety against collapse of at least one : that when the live load is applied after repair, the original steel will at first accept the load and the beam will deflect fractionally : immediately on deflection, that the new steel will begin to accept stress and the total load will be carried by both new and old steel, in

indeterminate proportions : that, as there was a factor of safety of at least unity prior to repair and the new steel doubles this, the ultimate factor of safety after repair is at least two.

This method is suitable for use where there may be good reason to believe that the real margin of safety is higher than assumed or where the expected life of a structure is fairly short, say 15 to 20 years.

Obviously if beams are more severely weakened (but not so badly as to entail reconstruction) or where deflection would be objectionable (e.g. in case 5), more steel should be added than as indicated above. In some cases, the added steel amounted to 50 per cent of the original steel.

Before deciding on the assumptions to be used in any individual case, it may be helpful to refer to the Report on Structural Safety (the STRUCTURAL ENGINEER, May 1955). The fundamental considerations set out therein are capable of being applied to repair works as well as to new construction.

Mr. Moran has never had the opportunity of carrying out loading tests on strengthened structures, but some of the earlier case histories in the paper were chosen so as to apply the acid test of behaviour under service conditions over a period of years. Mr. G. C. Pearson (Reference 5, Bibliography) has given a detailed description of loading tests on beams, columns and framed girders, and Dr. S. B. Hamilton has described a test on a strengthened slab (the STRUCTURAL ENGINEER, Feb. 1945, p. 91).

Correspondence

The Institution, whilst being at all times pleased to open its columns to correspondents, cannot accept responsibility for the opinions expressed.

To the Editor of THE STRUCTURAL ENGINEER

Load Distribution in Prestressed Concrete Bridge Systems

Sir,—We would refer to the above paper by Dr. P. B. Morice and Mr. G. Little, published in the STRUCTURAL ENGINEER of March 1954. Although the paper was published some time ago we feel that the following remarks regarding the tests on the continuous beam systems may still be of interest.

Using the method of analysis described by us in Vol. XV of the Publications of the International Association for Bridge and Structural Engineering the following values were found for the distribution coefficients for the longitudinals (expressed as fractions of the total deflection on each span) for the test with a single load at the mid point of the first span of longitudinal No. 1.

Loaded Span

	ρ_1	ρ_2	ρ_3	ρ_4
Writers Theory (No sinkage)	0.485	0.315	0.169	0.034
Writers Theory (Including sinkage)	0.474	0.309	0.171	0.046
Massonet Theory	0.474	0.309	0.169	0.048
Experimental	0.464	0.319	0.160	0.058

Unloaded Span

	ρ_1	ρ_2	ρ_3	ρ_4
Writers Theory (No sinkage)	0.428	0.321	0.183	0.067
Writers Theory (Including sinkage)	0.362	0.290	0.222	0.127
Massonet Theory	0.474	0.309	0.169	0.048
Experimental	0.320	0.270	0.230	0.180

The following conclusions may be drawn from these results :

(1) The distribution coefficients in the unloaded span are closer together than in the loaded span. In the Massonet theory as applied by the Authors the distribution coefficients are the same in both spans.

(2) Sinkage of the central supports which took place in the experiments has the effect of still further reducing the spread of the distribution coefficients in the unloaded span without greatly altering those in the loaded span.

(3) The writers method satisfactorily allows for the sinkage effect which was by no means negligible.

The sinkage of the central support in the experiment in fact masked the true distribution in the unloaded span and led the Authors to the erroneous conclusion that " the effects of distribution are virtually eliminated by a simple support and do not appear in the unloaded span of an unloaded specimen."

A more serious objection to the application of the Massonet theory to continuous bridges in the manner adopted by the Authors is that the deflected forms of the longitudinals are not geometrically similar. It is therefore incorrect to apply the Massonet coefficients to the deflected shape of a simple continuous beam. It is still further from the truth to attempt to distribute the bending moments in this way and indeed such a procedure is likely to result in serious error.

It is impossible to discuss the subject in the space of a short letter but it is fully dealt with in the publication referred to above and in other papers being published by us.

ARNOLD W. HENDRY (Member)
LESLIE G. JAEGER

To the Editor of THE STRUCTURAL ENGINEER

Load Distribution in Prestressed Concrete Bridge Systems

Sir,—Whilst we do not dispute the fact that the distribution coefficient theory based upon harmonic series does not provide a mathematically rigorous solution to the case of a continuous beam grillage we did think that the approximate application of this theory and comparison with our experimental values produced some interesting results.

Prof. Hendry and Dr. Jaeger omit reference to a torsionally stiff central support diaphragm when they report our statement " the effects of distribution are virtually eliminated by a simple support and do not appear in the unloaded span." Undoubtedly, the torsional stiffness must have the effect of reducing, if not always removing, the differences in beam deflexions.

Although deflected forms of the longitudinals should not have been exactly similar, the recorded deflexions at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ span sections showed excellent agreement with our modified theoretical values, which may well have been due to some settlement.

We welcome the contributions of Prof. Hendry and Dr. Jaeger in the field of bridge deck analysis and look forward to the results of their future work.

P. B. MORICE
G. LITTLE

Institution Notices and Proceedings

ORDINARY GENERAL MEETING

An Ordinary General Meeting of the Institution of Structural Engineers was held at 11, Upper Belgrave Street, London, S.W.1, on Thursday, 20th December, 1956, at 5.55 p.m. Mr. J. Guthrie Brown, M.I.Struct.E., M.I.C.E. (President) in the Chair.

The following members were elected in accordance with the Bye-Laws. Will members kindly note that the elections, as tabulated below, should be referred to when consulting the Year Book for evidence of membership.

Students

Caines, Graham Reginald, of Bristol.
Chandra, Tirtharenu, of London.
Edwards, William John Stephen, of Knutsford, Cheshire.
Hope, Barry Colin, of Portsmouth, Hants.
Jepson, Wilfrid John, of Manchester.
Johnstone, Brian Kenneth, of Port Elizabeth, South Africa.
Langdon, Norman, of London.
Noble, Alfred Henry, of Johannesburg, South Africa.
Richter, Colin Philip, of East London, South Africa.
Szyszko, Wiktor, of London.
Turner, Brian, of Bath, Somerset.
Wroe, Herbert Brian, of Harrogate, Yorkshire.

Graduates

Allott, John Thomas, B.Sc.(Eng.) London, of Rotherham, Yorkshire.
Burrington, John, of Chippenham, Wiltshire.
Dand, Shantilal Damji, B.E.(Civil) Bombay, of Mulund, (Dist. Thana), Bombay State, India.
David, Joseph Nissim, of London.
Dix, John Robert, of Middlesbrough, Yorkshire.
Fletcher, James, A.M.I.C.E., of Deganwy, Caernarvonshire.
Gray, Dennison, of Chesterfield, Derbyshire.
Gregory, Walter Henry, of Walsall, Staffs.
Guha Biswas, Satyendra Mohan, B.E.(Civil) Calcutta, of Patna, India.
Hinchliff, William Malcolm, B.Sc.(Eng.) London, of Kingston upon Hull.
Hodgson, Terence Park, of London.
Horsey, Ronald John, of Ilford, Essex.
Irving, Leslie, of Billingham, Co. Durham.
Madfai, Husham, of London.
Mookerjee, Malay Kumar, B.E.(Civil) Calcutta, of Stafford.
Mornement, Peter Clews, B.A. Cantab, of Hove, Sussex.
Munshi, Alauddin Abdullahmia, B.E.(Civil) Poona, of London.
Parker, Stanley, of Hyde, Cheshire.
Patel, Babubhai Shanabhai, of London.
Patil, Prabhakar Babaji, B.E.(Civil) Bombay, of London.
Pettett, John Watling, of Woking, Surrey.
Poddar, Shyam Sundar, B.Sc.(Eng.) Patna, of Bihar, India.
Ryan, Vincent John, of Liverpool.
Sanyal, Salil Kumar, B.E. Calcutta, D.I.C., of London.
Smith, Peter James, B.Sc.(Eng.) London, of Tadworth, Surrey.
Smith, Wilfred Collier, B.Sc.(Eng.) London, of Warrington, Lancs.
Spillett, Basil James, of Tonbridge, Kent.
Street, William Raymond, of Sale, Cheshire.
Thomas, John Windsor, of Swansea, Glam.
Thompson, Donald Charles, B.Sc.(Eng.) London, of Wealdstone, Middlesex.
Tompkins, David Edward Alfred, of Abridge, Romford, Essex.
Turton, Eric Victor William, B.Eng. Liverpool, of Upton, Wirral, Cheshire.

Associate-Members

Berry, Leonard James, B.Sc.(Eng.) London, of Derby.
McBrien, John, of Wishaw, Lanarkshire.

Members

Blake, Frederick Harrison James, of East Grinstead, Sussex.
Lambert, Alan Percival, M.Sc.(Eng.) London, M.I.C.E., of Bookham, Surrey.
Paterson, Kenneth, B.Sc.(Eng.) London, A.M.I.C.E., of Gainsborough, Lincs.
Tarin, Mohd Afzal Khan, B.Eng. Sheffield, of Lahore, Pakistan.
White, Douglas Eric, of East Horsley, Surrey.

Transfers

Students to Graduates

Claxton, Brian Hugh, of Ilford, Essex.
Endersby, Kenneth, of Leeds, Yorkshire.
Ettinger, Norman Barry, of Ilford, Essex.
Forman, Donald, of Middlesbrough, Yorkshire.
Hamill, John Gerald, of Leeds, Yorkshire.
McCarthy, Paul, of London.
Ratcliffe, Colin John, of West Kirby, Wirral, Cheshire.
Smith, Maven, of Sale, Cheshire.
Stinton, Gordon John, of Hunderton, Hereford.
Welford, Paul Alexander, of Chesham Bois, Bucks.

Graduates to Associate-Members

Crease, David Plaistow, M.A. Cantab., A.R.I.B.A., of Hong Kong.
Freiter, Ian Neville Ferguson, of Ontario, Canada.
Jolley, Dennis, of Bolton, Lancashire.
Knott, Stanley William, of Manchester.
Simmons, Maurice Arthur, of Sutton Coldfield, Warwicks.
Ward, James Arthur, of Bolton, Lancashire.

Associate-Members to Members

Best, Keith Howard, B.Eng. Sheffield, A.M.I.C.E., of Colombo, Ceylon.
Grave, Douglas Stuart, of Liverpool.
Lillicrap, George Cyril, B.Sc.(Eng.), London, A.M.I.C.E., of Johannesburg, South Africa.
Morton, Stanley Osborne, B.Sc.(Eng.) Belfast, M.I.C.E., of Belfast, Northern Ireland.
Osborne, Francis Victor, M.I.C.E., M.I.C.E.I., of Oxted, Surrey.
Sancha, Louis, B.Sc.(Eng.) London, D.F.C., M.I.C.E., of Portishead, Somerset.

Members to Retired Members

Brierley, George Albert, of Hadley Wood, Barnet.
Brown, Philip, M.I.Mun.E., of Stockton-on-Tees, Co. Durham.

Davison, William Robert, A.R.I.B.A., of Morpeth, Northumberland.
Gumersall, Gerald Joseph, B.Sc., M.I.C.E., M.I.Mech.E., M.I.E.E., of Worthing, Sussex.
Hanson, Arthur, of Bradford, Yorks.
Hedges, Walter Frederick, O.B.E., F.R.I.B.A., of Bournemouth, Hants.
Hogg, Peter Burns, of Joppa, Edinburgh, Midlothian.
Huke, Reginald William, of Southampton.
Hutchinson, William Franklin, of Chorlton-cum-Hardy, Manchester.
Jenkins, Lt.-Col. Ralph Emerson, A.M.I.C.E., F.R.I.C.S., of London.
Lister-Kaye, Sir Lister, Bart., Rugby, Warwicks.
McAndrew, George Douglas, O.B.E.(Mil.), M.I.C.E., of Otford, Sevenoaks, Kent.
MacKichan, Alexander Somerled, M.I.C.E., of Bexhill-on-Sea, Sussex.
Nicoll, James Patrick, L.R.I.B.A., of Wellington, New Zealand.
Perry, Joseph Henry, of Johannesburg, South Africa.
Robb, William Robertson, of Glasgow.
Rome, John Mackenzie, of Nailsea, Nr. Bristol.
Street, Thomas William, of London.
Warland, Edmund George, of Liverpool.
Watts, Thomas William, of Scarborough, Yorks.

Associates—Retired Associates

Gibbins, Sidney Charles, B.Sc. London, of Edgware, Middlesex.
Hale, Leslie Prior, L.R.I.B.A., of Middleton-on-Sea, Sussex.
Robson, Robert David, A.R.I.B.A., of Newcastle upon Tyne.

Associate-Members to Retired Associate-Members

Barron, Frank Edward, of Walsall, Staffs.
Brown, Capt. Gavin, of Newburgh, Fife.
Henegan, Gilbert Patrick Thomas, of London.
Lewis, Newton Mansel, of Truro, Cornwall.
Madeley, Cyril Edward Frederick, of Bude, Cornwall.
Morgan, William Charles, of Felixstowe, Suffolk.
North, Ronald William, M.I.Mun.E., of London.

Re-Admission

Member

Smith, Sidney Thomas, of Ewell, Surrey.

OBITUARY

The Council regret to announce the deaths of James Dallas, William John Green, George Dugan Mills (Members) and John Howard Moorby (Associate).

RESIGNATIONS

Notification was given that the Council had accepted with regret the resignations of Wilfred Francis Alderton, Lionel Thomas Broome (Members); Henry Brodrick, Cecil Walter Butson, Harold Pearson Foster (Retired Members); Alfred James Chapman, Ernest William Sadler (Associates); David Ritchie Calley, William Harold Cross, Paul Louis De Valence, William George Donaldson, Arthur Henry Eydmann, Hugh Duncan Findlay, George Louis Goddard, Francis Jack Laws, Arthur Malfaison, James Albert Morris, George Ernest Sewell, Frank Arthur Shorter, Alan Francis Gordon Stanham, Hugh Gordon Stanham, Herbert Samuel Tricker, Sydney Hamilton Wan Ping (Associate-Members); Albert William Anderson, John Stanley Appleby, Harold Trevor Astley, Dudley Layton Carey, Reginald Chase, Keith Henry Robson Cuthbert, Cyril Derrick Davies, Aubrey Keith Dugdale, Archibald Thompson Fairley, Stanley Gittins, Maneck Pestonji Golvala, Cecil William Franklin Hann, Stanley William Harvey, Leslie Nathan Henderson, Shrikishna Raghunath Kshirsagar, William Job Larnach, Roy Matthews, Michael Graeme Murray, Norman William Pidgeon, Brian Rhodes, Michael Alwyn Selfe, John Whitaker Sparks, John Cottam Thatcher, Eric Bone Thomson, Harold Wilson, Stanley Cempson Wright (Graduates); Donald Herbert Aldred, John Frederick William Andre, Robert Edward Bright, Claude James Campion, Ivan Maurice Cooper, Alexander Coull, William Simon Fraser, William Edward Giles, Thomas Raymond Gravenall, Paul Ian Hargreaves, Arnold Jones, David Raymond Knight, William Addey Malherbe, Francis Neil Midmer, Clive Cowan Rutherford (Students).

FORTHCOMING MEETINGS

The following meetings will be held at 11, Upper Belgrave Street, London, S.W.1.

Thursday, February 14th, 1957

Ordinary Meeting, 6 p.m., when Mr. G. B. Godfrey, A.M.I.C.E. (Associate-Member) will give a paper on "Post-War Developments in German Steel Bridges and Structures."

Thursday, February 28th, 1957

Ordinary General Meeting for the election of members, 5.55 p.m., followed by an Ordinary Meeting at 6 p.m., when Mr. D. H. New, E.R.D., B.Sc.(Eng.), M.I.C.E. (Member) and Mr. R. Sanders (Member) will give a paper entitled "Factory in Concrete for the Pressed Steel Co., Ltd., Stratton St. Margaret."

Thursday, March 14th, 1957

Ordinary Meeting, 6 p.m., when Mr. B. Scruby (Member) will give a paper on "Structural Problems connected with Palletisation."

Thursday, March 28th, 1957

Ordinary General Meeting for the election of members, 5.55 p.m., followed by an Ordinary Meeting at 6 p.m., when Mr. H. C. Husband, B.Eng., M.I.C.E., M.I.Mech.E. (Member) and Mr. K. H. Best, B.Eng., A.M.I.C.E. (Member) will give a paper on "Some Recent Highway Bridges in Ceylon."

Thursday, April 25th, 1957

Ordinary General Meeting for the election of members only, 5 p.m.

EXAMINATIONS—JULY 1957

The Examinations of the Institution will next be held in the United Kingdom and Overseas on Tuesday and Wednesday, July 16th and 17th (Graduateship), and Thursday and Friday, July 18th and 19th (Associate-Membership).

OVERSEAS REPRESENTATION

The Council have appointed Dr. K. Billig (Member) to act as the Institution's Representative in West Pakistan for a period of five years in place of Mr. F. M. P. Arbuthnot, who has left the area.

ALUMINIUM DEVELOPMENT ASSOCIATION RESEARCH SCHOLARSHIP

A research scholarship in the use of light alloys in structural engineering is offered every third year by the Institution of Structural Engineers in collaboration with the Aluminium Development Association. The duration of the scholarship is two years and the value £600 per annum.

The next award will be made this year to date from October 1st, 1957.

Details and application forms are obtainable from the Secretary of the Institution of Structural Engineers. Completed application forms should be sent in to reach the Secretary by March 31st, 1957.

MACLACHLAN LECTURE COMPETITION, 1957

The closing date for the receipt of entries for the next Maclachlan Lecture Competition is Friday, March 29th, 1957. The general conditions of the competition are as follows :

1. The Institution of Structural Engineers shall institute a written lecture to be known as the Maclachlan Lecture and to be held annually.

2. The subject of the Lecture may be on any aspect of Structural Engineering as long as in every second year the subject shall be confined to steel structures.

3. Entrance into the competition for the Lecture shall be confined to Graduates and Associate-Members of the Institution who are under the age of 32 years.

4. All papers entered for the competition shall be submitted to assessors to be appointed by the Council of the Institution, and all such papers (including the prize-winning Lecture) shall be available for publication in the Journal of the Institution at the discretion of the Council.

5. No paper submitted shall have been published or read elsewhere.

6. The winner of the competition shall be required to present the Lecture to a meeting of the Institution at which he will be presented with the sum of £17 10s.

7. Should a competitor's paper be considered worthy of ranking second in merit he will receive a consolation award of £5.

8. In the event of there being no winner of the competition in any one or more years, whether because no lecture submitted is considered to be of sufficient merit to warrant award, or for any other reason, the Institution shall transfer the above sums to the Research Fund of the Institution.

Particulars of the Competition for 1957

1. The Maclachlan Lecture will be given at a meeting of the Institution to be arranged towards the end of 1957.

2. The subject of the Lecture shall be confined to steel structures.

3. The work should be submitted as the script of a lecture which the Author, if successful in the competition, will deliver before an audience in the course of about one hour. The development of mathematical formulæ and detailed calculations should be avoided as far as possible in the text ; if they are essential they should be embodied in appendices. Photographs, drawings, graphs, etc. which would appear as illustrations to the lecture in published form, should accompany the script. If additional illustrations would be shown as slides, a list of these should be included.

4. Six copies of each Lecture should be submitted and should be addressed to the Secretary of the Institution.

5. The closing date for the receipt of entries by the Institution is Friday, March 29th, 1957.

DRURY MEDAL AWARD

The conditions governing the Drury Medal Award have been modified. The Competition is now open to Graduates and Students of the Institution up to the age of twenty-seven years and competitors will in future have the choice of alternative subjects.

The Sixth Competition for the Drury Medal Award will take place in 1957. The alternative subjects are as follows :—

(*a*) The design of a bunker installation in a gravel pit.

(*b*) The design of a diving platform suitable for use in Olympic and National competitions.

Graduates and Students of the Institution who wish to compete are invited to apply for full details to the Secretary, envelope to be marked in the top left-hand corner " Drury Medal Award."

The closing date for the competition is *October 1st*, 1957.

The general conditions of the competition are as follows :—

(1) The competition shall be for Graduates and Students of not more than 27 years of age.

(2) The subjects of the competition will be designs of a structural character, that is to say, involving structural design rather than planning.

(3) The subjects of design and the conditions shall be prepared and issued biennially.

(4) A Jury shall be appointed to examine the work submitted and to interview candidates if found necessary.

(5) In order to ensure that the design submitted is the unaided work of the competitor, the drawings, calculations etc., submitted shall be endorsed by the candidate : " I declare that the work I hereby submit is my own unaided work." The declaration shall be signed by the competitor, and be either countersigned by a corporate member, or be certified as made before a Justice of the Peace, or a Commissioner for Oaths.

LONDON GRADUATES' AND STUDENTS' SECTION

Messrs. Neo Poh Choon, Tsang Foh Kwei, and H. S. Bull have been elected members of the Committee. Messrs. Wong Gai Hong and J. D. Batra have resigned from the Committee owing to pressure of other work.

The following meetings will be held at 11, Upper Belgrave Street, London, S.W.1 :

Tuesday, February 12th, 1957

Mr. D. R. R. Dick, B.Sc., M.I.Struct.E., M.I.C.E., on " Structural Engineering and Atomic Energy," 6.30 p.m.

Tuesday, March 5th, 1957

Paper on " Building in Timber," 6.30 p.m.

Monday, April 1st, 1957

Films and Annual General Meeting.

Hon. Secretary : B. J. Rushton, 21, Markham Street, London, S.W.3.

ADDITIONS TO THE LIBRARY

American Institute of Steel Construction. Welded Tapered Girders. New York : 1956. Presented by Mr. G. Bernard Godfrey.

A.S.T.M. Year Book, September, 1956. *Supplements to Book of A.S.T.M. Standards, including Tentatives, Parts 2 and 7.* Philadelphia, 1956.

BAKER, A. L. L. *The Ultimate-Load Theory applied to the Design of Reinforced and Prestressed Concrete Frames.* London : 1956. Presented by Professor R. H. Evans.

British Constructional Steelwork Association. Publication No. 10. *Some Notes on the Analysis of Rigid Frames.* London : 1956.

Cement and Concrete Association. The Analysis of Right Bridge Decks subjected to Abnormal Loadings, by P. B. Morice and G. Little.

Single Storey Industrial Buildings. An Appreciation of the Work carried out on Fatigue in Prestressed Concrete Structures, by R. E. Rowe.

Technical Report No. TRA/230. *Analysis of Cylindrical Prestressed Concrete Tanks,* by G. C. Reynolds and P. B. Morice.

Technical Report No. TRA/232. *Some Tests on the Effect of Time on Transmission Length in Pre-Tensioned Concrete,* by G. D. Base.

Technical Report No. TRA/235. *The Bond Strength of Sherardized and Zinc-Sprayed Reinforcement,* by K. E. Robinson.

London : 1956.

COTTRELL, C. L. M., WINTERTON, K., and BRADSTREET, B. J. *The Weldability of High-Tensile Structural Steels.* London : B.W.R.A., 1956.

CRANE, T. *Architectural Construction. The Choice of Structural Design.* 2nd Edition. New York and London : 1956.

DEARDEN, J. *Iron and Steel Today.* 2nd Edition. London : 1956.

Department of Scientific and Industrial Research, Road Research Laboratory. Technical Paper No. 35. *Concrete Roads in Belgium and Western Germany,* 1954. *Their Structural Design and Performance.* London : 1955.

DURIEZ, M. M. *Plasticisers and Air-Entraining Agents for Concrete.* Translation. London : Sika Ltd., 1956.

GIBSON, J. E. *A Mathematical and Photo-Elastic Investigation of the Stress Distribution under Foundations.* (University of Durham, King's College Bulletin, No. 5, 1956.) Presented by the Author.

HENRY, F. D. C. *Design and Construction of Engineering Foundations.* London : 1956. Presented by Mr. G. B. Brown.

HOLLAND, H. L. *Design of Multi-Storey Steel Frame Buildings.* (Pamphlet.) Richmond, Surrey, 1956.

International Symposium on Non-Destructive Testing of Materials and Structures. Paris.

KOLLBRUNNER, C. F. and MEISTER, M. *Knicken : Theorie und Berechnung von Knickstäben. Knickvorschriften. (Buckling. Theory of Buckling, Calculation of Buckling Strength, Specifications.* Berlin : 1955. Presented by Dr. Hajnal-Konyi.

NEWMARK, N. M. *An Engineering Approach to Blast-Resistant Design.* University of Illinois, 1956.

Northern Aluminium Company, Limited. Structural Aluminium. Banbury, Oxon, 1956.

NYLANDER, H. *Design of Two-Way Concrete Slabs.* (In Swedish, with English Summary.) Stockholm : 1955.

NYLANDER, H. and SAHLIN, S. *Investigation of Continuous Concrete Beams at Far-Advanced Compressive Strains in Concrete.* (In Swedish, with English Summary.) Stockholm : 1955.

SAHLIN, S. *Effect of Far-Advanced Compressive Strains of Concrete in Reinforced Concrete Beams submitted to Bending Moments.* (In Swedish, with English Summary.) Stockholm : 1955.

SEELYE, E. E. *Foundations. Design and Practice.* New York and London : 1956. Presented by Dr. W. Eastwood.

Soil Mechanics Ltd. A Handbook of Site Investigation, Geotechnical Processes and Constructional Devices. London : 1956. Presented by the Publishers.

THOMPSON, A. G. *Arc-Welded Machinery Construction in Mild Steel.* London : 1956. (Pamphlet.)

YOUNG, C. R. and DUNBAR, W. B. *Net Sections of Drilled Plates.* University of Toronto, 1926. Presented by Mr. W. Basil Scott.

BRANCH NOTICES

LANCASHIRE AND CHESHIRE BRANCH

The following meetings have been arranged :

Friday, February 1st, 1957

Annual Dinner and Dance at the Midland Hotel, Manchester.

Wednesday, February 13th, 1957

At the College of Building, Liverpool, at 6.30 p.m., Mr. A. V. R. Hooker, M.I.Struct.E., M.I.C.E., on " Welded Steel Structures."

Thursday, February 14th, 1957

The above meeting will be repeated in Manchester.

Wednesday, February 20th, 1957

At the Liverpool Engineering Society's Room, 24, Dale Street, Liverpool, at 6.30 p.m. Joint Lecture with the Institution of Civil Engineers.

Dr. P. B. Morice, B.Sc.(Eng.), A.M.I.Struct.E., A.M.I.C.E., on " The Analysis of Prestressed Concrete Structural Members and the Application of Recent Research."

Tuesday, March 19th, 1957

Professor R. H. Evans, D.Sc., Ph.D., M.I.Struct.E., M.I.C.E., M.I.Mech.E., on " Some Aspects of Research Work on Prestressed Concrete."

Unless otherwise stated meetings will be held at the College of Technology, Manchester, at 6.30 p.m., and will be preceded by light refreshments.

Joint Hon. Secretaries : J. L. Robinson, A.M.I.Struct.E., 314, Northernden Road, Sale, Cheshire ; M. D. Woods, A.M.I.Struct.E., 58, Spring Gardens, Salford, 6.

MIDLAND COUNTIES BRANCH

The following meetings have been arranged :

Wednesday, February 6th, 1957

At the Wolverhampton & Staffordshire Technical College, Wulfruna Street, Wolverhampton, at 7 p.m., Mr. J. S. Allen, A.M.I.C.E. (Graduate) on " The Application of Welding to Structural Steelwork."

Friday, February 22nd, 1957

Joint Meeting with the Reinforced Concrete Association, Midland Counties Branch. Mr. Walter C. Andrews, O.B.E., M.I.C.E. (Past-President) on " Revisions to CP.114 (1948)."

Wednesday, March 13th, 1957

The above paper will be repeated at the Becket Sale Room, Becket Street, Derby, at 6.15 p.m.

Friday, March 22nd, 1957

Mr. R. Bolsover, A.M.I.Struct.E., Mr. M. D. Picknell, A.M.I.Struct.E., and Mr. E. J. Spillett on " Structural Aspects of the ' Big Top ' Site Development."

Tuesday, April 2nd, 1957

At the Mechanics Institute, Nottingham, at 6.15 p.m., talk by Mr. Ove N. Arup, C.B.E., M.I.Struct.E., M.I.C.E.

Friday, April 26th, 1957

Annual General Meeting, followed by films on Prestressed Concrete.

Unless otherwise stated, all meetings will be held at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 6 p.m.

Hon. Secretary : J. R. Chaffer, M.I.Struct.E., 107, Jockey Road, Sutton Coldfield, Warwickshire.

MIDLAND COUNTIES GRADUATES' AND STUDENTS' SECTION

The following meetings have been arranged :

Friday, February 1st, 1957

Mr. A. G. Osborne, A.M.I.C.E., on " Erection Procedure—with Special Reference to Erectors' Problems."

Friday, March 1st, 1957

Mr. G. F. Wilson (Graduate) (Past-Chairman of the Section) on " Handling of Iron Ore in Steel Works."

Friday, April 12th, 1957

Address given by the Branch Chairman, followed by the Annual General Meeting.

All meetings will be held at the Birmingham Exchange and will start at 6.30 p.m.

Hon. Secretary : J. E. Jeffries, 18, Radnor Road, Handsworth, Birmingham, 23.

NORTHERN COUNTIES BRANCH

The following meetings have been arranged :

Tuesday, February 5th, 1957 (Middlesbrough)

Wednesday, February 6th, 1957 (*Newcastle*)

Mr. G. Bernard Godfrey, A.M.I.Struct.E., A.M.I.C.E., on " Joints in Steel Rigid Frameworks."

Tuesday, March 5th, 1957 (*Middlesbrough*)

Wednesday, March 6th, 1957 (*Newcastle*)

Mr. W. S. Atkins, B.Sc., M.I.Struct.E., M.I.C.E., on " Abbey Steelworks."

Tuesday, April 2nd, 1957

Annual General Meeting. Lecture to be arranged.

Meetings in Middlesbrough will be held in the Cleveland Scientific and Technical Institution.

Meetings in Newcastle will be held in the Neville Hall.

Meetings will commence at 6.30 p.m. preceded by a buffet tea at 6 p.m.

Hon. Secretary : H. W. Dowe, A.M.I.Struct.E., 143, Laburnum Road, Redcar, Yorks.

NORTHERN IRELAND BRANCH

The following meetings have been arranged :

Tuesday, February 5th, 1957

Address by a speaker from Soil Mechanics, Ltd., on " Practical Applications of Soil Mechanics."

Tuesday, March 5th, 1957

At the Grand Central Hotel, Belfast, at 6.30 p.m., Annual Dinner and Social Function.

Visit by the President and Secretary of the Institution.

Tuesday, April 2nd, 1957

Film Evening.

May. Annual General Meeting. Election of Honorary Officers. Date to be arranged.

Meetings will be held at the College of Technology, Belfast, at 6.45 p.m., unless other notification is given, and will be preceded by tea at the Overseas League premises, Wellington Place, Belfast, at 6 p.m.

Hon. Secretary : A. H. K. Roberts, B.A., B.A.I., M.I.Struct.E., M.I.C.E.I., Barbizon, 26, Dunlambert Park, Belfast.

SCOTTISH BRANCH

The following meetings have been arranged :

Friday, February 22nd, 1957

Joint Meeting with the Glasgow and West of Scotland Association of the Institution of Civil Engineers.

Mr. J. A. Banks, O.B.E., M.I.C.E., on " Allt-Na-Lairige Prestressed Concrete Dam," at 7.15 p.m.

Tuesday, March 19th, 1957

Mr. Andrew Young, A.M.I.Mech.E., on " Construction of New Iron and Steel Works—Messrs. Colvilles, Ltd., Ravenscraig, Motherwell," at 7 p.m.

Tuesday, April 9th, 1957

At Ca'doro Restaurant, Union Street, Glasgow, 7 p.m. (High Tea from 6 p.m..) Annual General Meeting.

Meetings will be held at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, at 7 p.m. unless otherwise stated.

Hon. Secretary : W. Basil Scott, M.I.Struct.E., 19, Waterloo Street, Glasgow, C.2.

SOUTH-WESTERN COUNTIES BRANCH

The following meetings have been arranged :

Friday, February 2nd, 1957

At the Duke of Cornwall Hotel, Plymouth, at 7 p.m. Films on " Bridging " and " Welding."

Friday, March 22nd, 1957

At the Duke of Cornwall Hotel, Plymouth, at 6 p.m. (Tea will be served at 5.30 p.m.)

Joint Meeting with the Plymouth Section of the Western Counties Branch of the Institution of Civil Engineers. Mr. S. P. Whittington, A.M.I.C.E., on " Law and the Engineer."

Friday, April 12th, 1957

Mr. J. Singleton-Green, M.Sc., M.I.C.E., A.M.I.Mech.E. (Member of Council) at Truro, on " Some Developments in Concrete Engineering."

Hon. Secretary : C. J. Woodrow, J.P., " Elstow," Hartley Park Villas, Mannamead, Plymouth, Devon.

WALES AND MONMOUTHSHIRE BRANCH

The following meetings have been arranged :

February, 1957

Joint Meeting with the Institution of Welding at Cardiff.

Tuesday, February 21st, 1957

Joint Meeting with the Institution of Municipal Engineers. " Demonstration of Applying Single-wire Prestressing." At Swansea.

Tuesday, March 5th, 1957

Mr. J. M. Burke, M.A., A.M.I.Struct.E., on " The Design of Aircraft Hangars," at Cardiff.

Wednesday, March 20th, 1957

Junior Members' Papers.

Talk by W. H. Bartlett, M.I.Struct.E., entitled " The Structural and Civil Engineer in the Colonial Service." At Swansea.

Friday, April 12th, 1957

Annual Dinner at Swansea.

Tuesday, April 30th, 1957

Mr. H. Ferrington, M.I.Struct.E., on " Wind Stresses on Buildings." At Cardiff.

Meetings at Cardiff will be held at the South Wales Institute of Engineers, Park Place, at 6.30 p.m.

Meetings at Swansea will be held at the Mackworth Hotel, at 6.30 p.m.

Hon. Secretary : K. J. Stewart, A.M.I.Struct.E., A.M.I.C.E., 15, Glanmor Road, Swansea, Glam.

WESTERN COUNTIES BRANCH

The following meetings have been arranged :

Friday, February 1st, 1957

Paper by Mr. Felix J. Samuely, B.Sc.(Eng.), M.I.Struct.E., M.I.C.E.

Wednesday, February 13th, 1957

Annual Dinner, Royal Hotel, Bristol.

Friday, March 1st, 1957

Mr. W. H. Diamond, B.A., M.I.C.E., on " Some Practical Aspects of Recent Structural Welding Developments."

Friday, April 5th, 1957

Annual General Meeting to be followed by talk given by Mr. J. Erby, A.M.I.Struct.E., in connection with his recent tour of duty in the West Indies.

Thursday, April 11th, 1957

Combined Meeting with the Institution of Civil Engineers. Mr. R. P. Mears, B.A., M.I.Struct.E., M.I.C.E., and Mr. E. E. Pool, A.M.I.C.E., on " The Design of Neath and Brighton Ferry Viaducts."

Meetings will be held in the Small Lecture Theatre in the New Engineering School, University of Bristol., at 6 p.m., preceded by tea at 5.30 p.m.

Hon. Secretary : E. Hughes, M.I.Struct.E., 23, Southdown Road, Westbury-on-Trym, Bristol, 9.

YORKSHIRE BRANCH

The following meetings have been arranged :

Thursday, February 14th, 1957

Joint Meeting with the Yorkshire Association of the Institution of Civil Engineers at the Royal Victoria Hotel, Sheffield, at 7 p.m.

Mr. H. C. Husband, B.Eng., M.I.Struct.E., M.I.C.E., M.I.Mech.E., on " Structural and Civil Engineering Aspects of Factory Design."

Wednesday, February 20th, 1957

Mr. H. C. Husband, B.Eng., M.I.Struct.E., M.I.C.E., M.I.Mech.E., on " Structural and Civil Engineering Problems in Factory Design."

Wednesday, February 27th, 1957

Joint Meeting with the Yorkshire Association of the Institution of Civil Engineers at Scunthorpe.

Mr. R. A. Sefton Jenkins, B.Sc., A.M.I.Struct.E., A.M.I.C.E., on " Pre-stressed Steel Lattice Girders."

Thursday, March 7th, 1957

Joint Meeting with the Yorkshire Association (Hull and East Riding Branch) of the Institution of Civil Engineers, at the Lecture Theatre, Electricity Building, Ferensway, Hull, at 6.15 p.m.

Mr. W. H. C. Piling, B.A., M.E.E., on " Nuclear Power Station Construction."

Wednesday, March 20th, 1957

Mr. J. O. C. Ritchie, on " Concrete Water Towers."

Friday, March 22nd, 1957

Annual Dinner and Dance at the Parkway Hotel, Lawnswood, Leeds, 7 p.m.

Wednesday, April 17th, 1957

Annual General Meeting.

Mr. J. R. Malcolm, B.Sc., M.I.C.E., and Mr. J. A. Lewis, M.B.E., B.A., A.M.I.C.E., on " Civil Engineering Construction under Water."

All meetings will be held at the Central Electricity Authority Offices, Whitehall Road, Leeds, at 6.30 p.m., unless otherwise stated.

Hon. Secretary : E. Wrigley, A.M.I.Struct.E., 17, The Drive, Alwoodley, Leeds.

UNION OF SOUTH AFRICA BRANCH

Hon. Secretary : A. E. Tait, B.Sc., A.M.I.Struct.E., A.M.I.C.E., P.O. Box 3306, Johannesburg, South Africa.

During weekdays, Mr. Tait can be contacted in the City Engineer's Department, Town Hall, Johannesburg. Phone : 34-1111, Ext. 257.

Natal Section Hon. Secretary : L. A. A. Lang, A.M.I.Struct.E., P.O. Box 932, Durban.

Cape Section Hon. Secretary : R. Stubbs, M.I.Struct.E., African Guarantee Building, 8, St. George's Street, Cape Town.

EAST AFRICAN SECTION

Chairman : R. A. Sutcliffe, M.I.Struct.E.
Hon. Secretary : L. A. Spooner, A.M.I.Struct.E., P.O. Box 6218, Nairobi, Kenya.

SINGAPORE AND FEDERATION OF MALAYA SECTION

Chairman : T. Karmakar, M.I.Struct.E.
Hon. Secretary : W. N. Cursiter, B.Sc., A.M.I.Struct.E., c/o Redpath Brown and Co. Ltd., P.O. Box 648, Singapore.

COSTAIN CONCRETE CO. LTD.

DUNCAN HOUSE, DOLPHIN SQUARE, LONDON, S.W.1.

TELEPHONE:— VICTORIA 3172/4

for High Quality Precast and Prestressed Concrete

LONDON UNIT FACTORY

Stahlton Lane, Southend Arterial Road
Childeritch, Nr. Brentwood, Essex
Tel.: Herongate 317

SCOTLAND

COLTNESS FACTORY
Newmains, Lanarkshire
Tel.: Motherwell 2331

LANCS., YORKS & MIDLANDS

R. Costain & Sons (Liverpool) Ltd.
Barlows Lane, Fazakerley, Liverpool 9.
Tel.: Aintree 4141/5

WALES

Cowbridge Road
BRIDGEND, *Glamorgan*
Tel.: Bridgend 961

Also Manufacturers of

Stahlton PRESTRESSED FLOORS

No. 3 OF A SERIES SHOWING TECHNICAL DEVELOPMENTS IN CONCRETE CONSTRUCTION

BOTTLING HALL

EXTENSION

THE BREWERY, READING

Prestressed concrete

-the new economy in building



The main beams of this extension were pre-cast solid section units 22 ft. long by 20 in. deep, tapering in width from 13 in. at the top to 8 in. at the bottom. Secondary beams were 30 ft. span by 40 in. wide by 17 in. deep of hollow box section to be transversely prestressed after erection.

* *Some further details of this project and others are published in brochure form. Write for your copy now.*

Sponsor: H. G. Simmonds Ltd., Reading.
Architect: R. E. J. Southall, A.R.I.B.A. Reading.
Designer: Pre-Stressed Concrete Co. Ltd., London, S.W.1.
Contractors: Vibrated Concrete Construction Co. Ltd., London, S.W.1.

Ever since prestressed concrete construction was first used in this country, designers, architects and civil engineers have specified "Wire by Johnsons." The reason is quality built up on early experimental work with those specialist designers who studied and worked in the Continental development of this new building technique.

Johnsons have a long record of "Firsts" including indented wire for greater bonding and coils of 8ft. diameter, from which the wire pays out straight.

wire was essential—

Johnsons the choice!

Richard Johnson & Nephew Ltd., Manchester, 11

Building the modern way

Flats in the Picton Street development scheme undertaken by the London County Council.
Architects: L.C.C. Architects Department,
Contractors: John Laing & Son Ltd.





and using Aluminium to do it

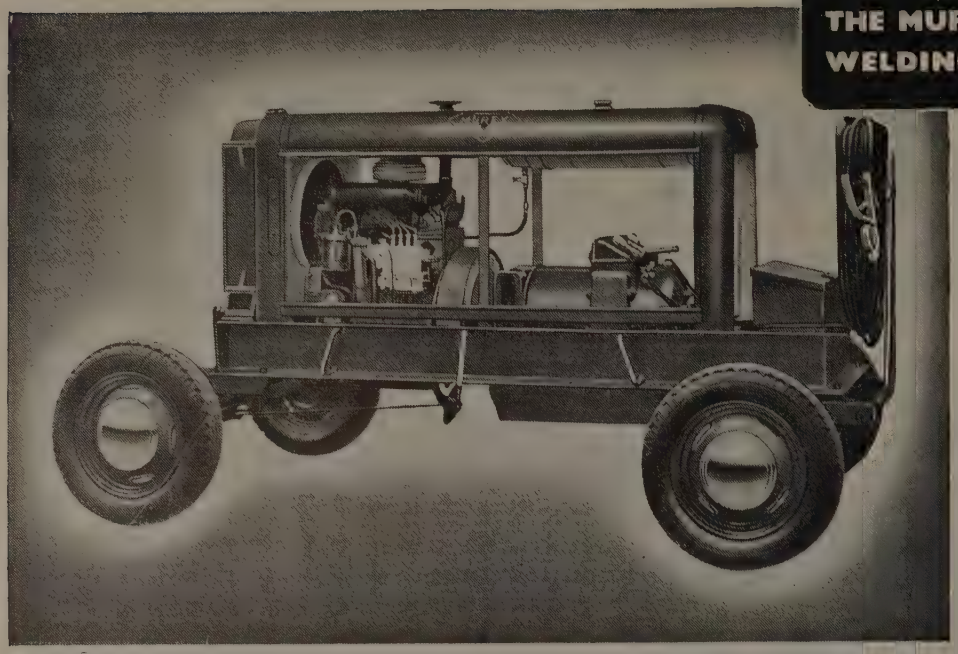
In these new eleven storey blocks of flats aluminium is strongly featured. The droppers connecting the five balconies are in aluminium alloy, as are the balcony side and front screens and also the rainwater fittings. All were supplied by Hawksley SMD. Aluminium—light, strong, pleasing in appearance and highly resistant to corrosion—is setting the pace in modern building. So, too, are Hawksley SMD. Whatever the type of aluminium structure involved, the experience of Hawksley SMD is readily available to architects and builders. From initial design to final completion, they provide a unique service.

That's the job of

HAWKSLEY SMD

World Leaders in Aluminium Structures

SLOUGH · BUCKS : TELEPHONE: SLOUGH 23212 · *A member of the Hawker Siddeley Group*



THE MUREX 'OVERLANDER' ARC WELDING SET FOR SITE WORK

The Murex Overlander 300/400amp single operator arc welding set has special rugged characteristics for open site work. It is substantially built on an undercarriage having a low centre of gravity and a wide track width to ensure stability. It has independent wheel springing and turntable front wheels for mobility and manoeuverability. The equipment is driven by a powerful industrial diesel engine* and it incorporates the well-known Murex Dynex welding generator which gives infinite current adjustment throughout its entire range. The voltage can also be independently and infinitely adjusted between maximum and minimum values. Please write for full details.

** The standard set has a Perkins P4 diesel engine but any other suitable engine can be fitted if required.*

Incorporating the unique MUREX DYNEX ***generator***

MUREX

ELECTRIC ARC WELDING EQUIPMENT & ELECTRODES

MUREX WELDING PROCESSES LTD., WALTHAM CROSS, HERTS.
Telephone: Waltham Cross 3636

E22

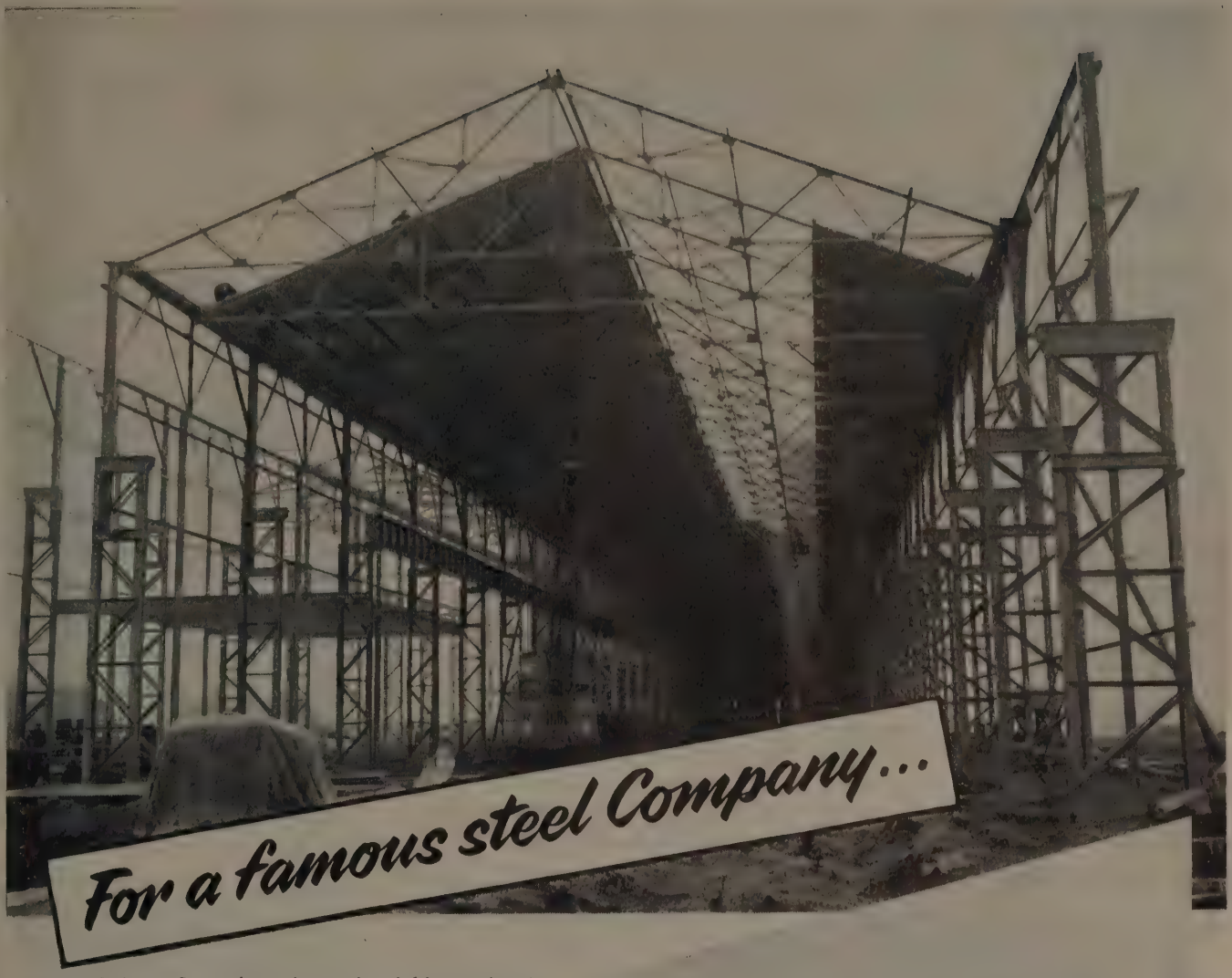
PIONEERS OF CAST IN SITU PILING

SIMPLEX PILES

SIMPLEX CONCRETE PILES LTD

25, BRECHIN PLACE, SOUTH KENSINGTON, S.W.7

Telephone: FREmantle 0035/6



For a famous steel Company...

Rubery Owen have designed and fabricated and are erecting the steelwork for the new Alphasil extension of Messrs. Richard Thomas & Baldwins Ltd.

The complete structure will comprise one bay 1,260 ft. long of 60 ft. span, a lean-to 210 ft. long and 30 ft. span, and two 870 ft. bays of 60 ft. and 70 ft. spans.

Complete with welded plate crane girders.

Total weight of steelwork - 1500 tons.



New Alphasil extension for Messrs. Richard Thomas & Baldwins, Ltd., at their Cookley Works, Brierley Hill.



structural steelwork

BY

RUBERY OWEN

Member of the OWEN Organisation

THE BACKBONE OF GOOD BUILDING

RUBERY OWEN & CO. LTD. STRUCTURAL DIVISION, P.O. Box 10, DARLASTON, WEDNESBURY, STAFFS.

Technical Bureaux : Birmingham, London, Coventry, Southampton

CONTACT **PYNFORD LTD** FOR A

Complete Foundation Service

★ **SITE INVESTIGATIONS** that are clear and to the point.

★ **NEW FOUNDATIONS** designed and/or constructed to suit all site conditions.

★ **UNDERPINNING** by the proved **Pynford method** for high level beams, or below ground level.

★ **JACKING** Re-levelling existing buildings and cheap provisions for new buildings.

★ **EXCAVATING SHIELDS** supplied for digging to any depth through shifting ground such as sand mixed with water.

Illustrated brochure will be despatched to you on request. Write or 'phone any query to

Speedy Site Investigations. Foundation Design and Construction. Piling, Underpinning, Controlled Jacking, Mining Subsidence Control. Beams at High Level, Basements under Existing Buildings, Excavating Shields supplied. Structural alterations.

Pynford Limited *Foundation Engineers*

Patentees

74 LANCASTER ROAD, STROUD GREEN, LONDON, N.4. Tel: ARChway 6216/7

BUCKLERSBURY HOUSE TO STAND ON



3,500 BORED PILES

This important Office Building in the City of London, 17 storeys high including the basement floors, is supported on Cementation Bored Piles. Approximately 3,500 were constructed well within the contract time despite the fact that delays were unavoidably occasioned by the deliberations on the fate of the Mithras Temple discovered on the site and other major difficulties inevitable on such a large site.

The construction of a surrounding wall to retain the adjoining Queen Victoria Street, Cannon Street and Bucklersbury was greatly facilitated by the use of our bored piles.

The close proximity of important buildings including the Mansion House and services such as the Underground Railway made it necessary to reduce noise, vibration etc., to an absolute minimum.

The CEMENTATION COMPANY LIMITED

London Office: 39 Victoria St., S.W.1 Tel: ABBey 5726

BENTLEY WORKS, DONCASTER · *Tel:* 54175-6-7-8-9

Proof that RUSTODIAN really stays on NEW GALVANIZING

NEW GALVANIZED IRON—UNTREATED



Rustodian Primed

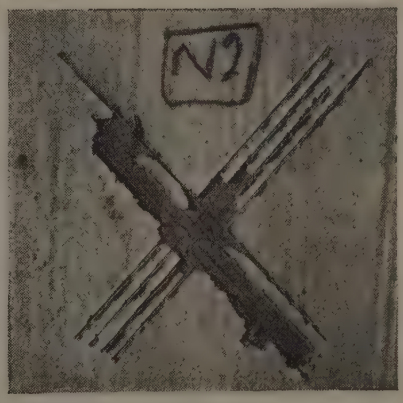


Non-Calcium Plumbate Primed

NEW GALVANIZED IRON—WASHED WITH WHITE SPIRIT



Rustodian Primed



Non-Calcium Plumbate Primed

These are actual size reproductions of scratch marks made after two years exposure and photographed after a further exposure of five months. Note the exceptional adhesion of the Rustodian primed film.

Priming new galvanized iron or steel is a problem no more. RUSTODIAN, a **calcium plumbate** primer, goes on with the least preparation and stays on for longer than anything previously used.

No more mordant solutions, no more waiting for weathering; just a quick wash down with white spirit—and galvanizing is ready for Rustodian. Then what happens? These photographs tell their own story. They are actual size reproductions of scratch marks made on test panels after two years exposure and photographed after a further exposure of five months. Note the exceptional adhesion of the Rustodian primed film.

Rustodian is available in six colours and supplied in the usual trade packages up to 5 gallon drums.

Rustodian is based on calcium plumbate, a pigment developed by Associated Lead Manufacturers Limited, and is one of the most powerful rust inhibitors known.

Manufactured under British Patent No. 574826.



ASSOCIATED LEAD

* *Associated Lead Manufacturers Limited is a single Company which specialises in the manufacture of Lead Pigments and Lead Paints.*

IBEX HOUSE, MINORIES, LONDON, E.C.3.
CRESCENT HOUSE, NEWCASTLE.
LEAD WORKS LANE, CHESTER.

ASSOCIATED LEAD PRODUCTS

Export enquiries to: THE ASSOCIATED LEAD MANUFACTURERS EXPORT CO. LTD., IBEX HOUSE, MINORIES, LONDON E.C.3.

STENT

PRECAST CONCRETE PILES



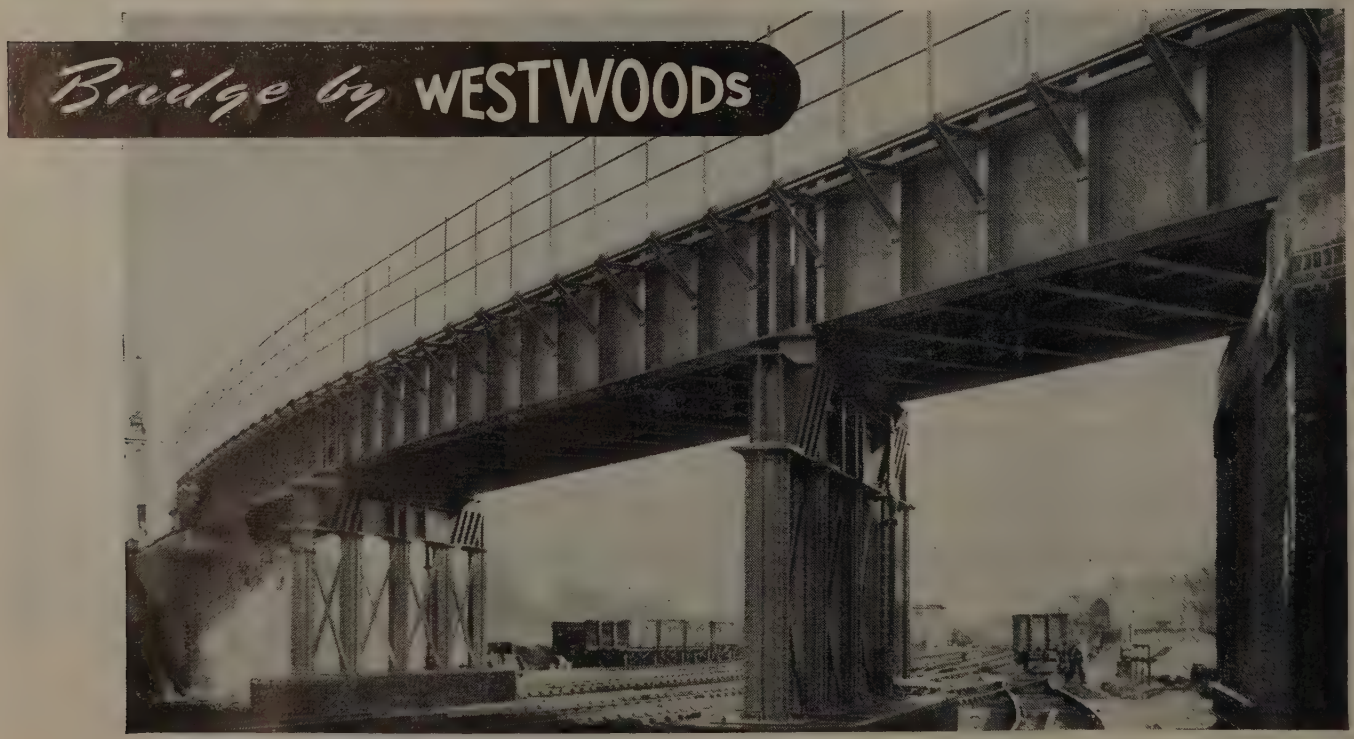
Preferred by constructional engineers for their unchanging supremacy, Stent Precast Concrete Piles have proved their qualities wherever used.

AVAILABLE FOR IMMEDIATE DELIVERY

May we forward full details

STENT PRECAST CONCRETE LTD. Sales Office: 1, Victoria Street, London, S.W.1. Tel: Abbey 2573
Head Office & Works: Dagenham Dock, Essex. Tel: Rainham (Essex) 780

Bridge by **WESTWOODS**



TWICKENHAM FLYOVER. This bridge is curved in plan, and each of the three spans was completely welded at works and delivered by road and rail to the site. Max. length 75 ft., width 15 ft.

JOSEPH WESTWOOD & CO., LTD.

NAPIER YARD, MILLWALL. LONDON. E.14
Telephone: EASt 1043

Bridge and Constructional Engineers, Manufacturers of Mechanical Grabs, Pressed Steel Troughing and Sheet Metal Equipment. Steel Stock Holders.

3 ST. JAMES'S SQ. S.W.1 TRAFALGAR 7833

THE
DEMOLITION &
CONSTRUCTION
COMPANY LIMITED

Civil Engineering, Building and Public Works Contractors



New Jetty on River Thames for the South Eastern Gas Board



Construction of New Technical College for the Newport, Mon. Borough Council

Architect:
Sir Percy Thomas & Son

FWS

SMITH'S

2 WAY REINFORCED *FIREPROOF FLOORS*

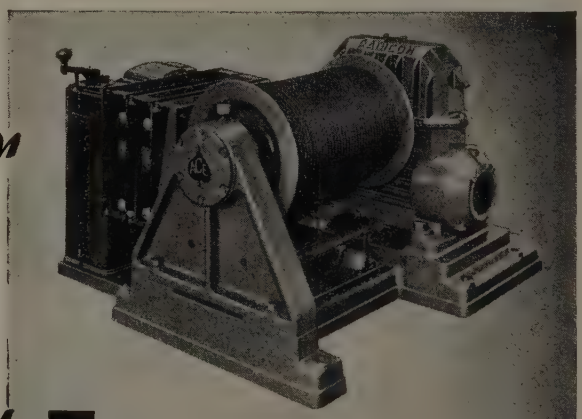


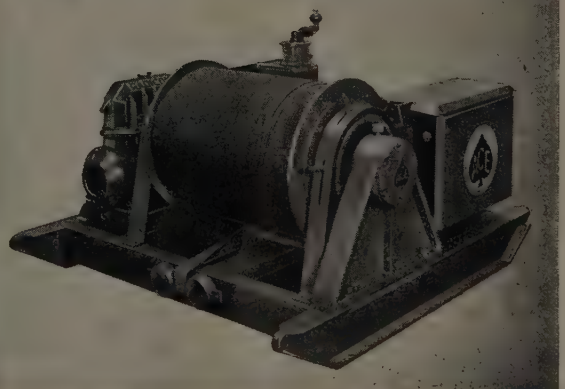
SMITH'S FIREPROOF FLOORS of Hollow Concrete Block construction are the result of considerable experiment and research to provide a floor, LIGHT in WEIGHT but suitable for LARGE or SMALL SPANS, HEAVY or LIGHT loading and able to sustain ABNORMAL POINT LOADS.

SMITH'S FIREPROOF FLOORS LTD.
Imber Court, East Molesey, Surrey. *'Phone: Emberbrook 3300.*

Midland Licensees :
PARKFIELD CONCRETE PRODUCTS CO. LTD.
ST. PETERS ROAD, NETHERTON, DUDLEY, WORCS.
Telephone : Dudley 4315.

A.C.E. *Winches for* Hauling, Lifting Construction *and* Erection





Standard and special types for steel erecting, skip hoists, transporters, wharf cranes, general haulage and building construction. Capacities from half ton (500 kilos) upwards.

Send for Full Particulars.

ACE

A.C.E. MACHINERY LIMITED
HARLEQUIN AVENUE, GREAT WEST ROAD, MIDDLESEX
Telephone EALing 6262 (5 lines) and at Brixton London S.W.2

ACE 58



Photograph by courtesy of Central Electricity Board.

THE FRANKI COMPRESSED PILE CO. LTD. · 39 VICTORIA STREET · LONDON SW1 · CABLES FRANKIPILE SOWEST LONDON

AND IN AUSTRALASIA · BRITISH WEST INDIES · IRAQ · RHODESIA · S. AFRICA

YORKSHIRE HENNEBIQUE

Contracting Co. Ltd.

ESTABLISHED 1904

CIVIL ENGINEERING CONTRACTORS

HEAD OFFICE:
HENNEBIQUE HOUSE
The Mount · York
Telephone: YORK 54656 (4 *lines*)

Branch Offices:
HULL: 30 WINCOMLEE. Telephone: Hull 33501.
DUNDEE: 1 WEST BELL ST. Telephone: Dundee 6170.
LEEDS: ROYDS WORKS, LOWER WORTLEY, LEEDS 12. Telephone: Leeds 637891.



McCall's
MATOBAR
Welded
FABRIC REINFORCEMENT

McCall's "MATOBAR" Fabric was used in Iraq for the Baghdad Highway, constructed by the United Construction Co. Ltd., of Baghdad.

McCALL & COMPANY (Sheffield) LTD., Templeborough, Sheffield. P.O. Box 41
Telephone: Rotherham 2076 (8 lines)
and at 8/10 GROSVENOR GARDENS, LONDON, S.W.1. *Telephone: Sloane 0428*

SRB 52

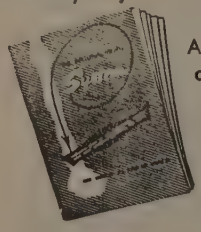


SAFE AS HOUSES

Eliminate vibration when piling—and you eliminate the risk to existing adjacent property, and the complications which arise from underpinning or replacing existing structures.

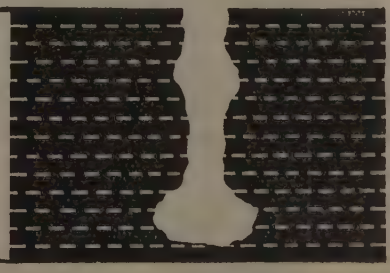
Pressure Piling is established as the correct method of piling without vibration—in fact insurance companies are prepared to offer low premium rates to cover adjoining property against damage when this method is used. For safety's sake specify *Pressure Piling* and the problems of piling in confined spaces, inside existing buildings, in waterlogged strata and in water, will be solved at once.

Consult Pressure Piling first and gain the benefit of a long and successful practical experience in "tricky" jobs.



Architects and Engineers are invited to write or phone us for a copy of "The Pressure Piling System." This informative booklet gives you technical data on piled foundations and underpinning for rapid vibrationless construction and repairs. It is free and post-free.

THE PRESSURE PILING COMPANIES



THE PRESSURE PILING COMPANY (PARENT) LTD
637 OLD KENT ROAD, LONDON, S.E.15 *Telephone: New Cross 0347/8/9*

Enquiries for the North of England, Scotland, Northern Ireland and Eire should be addressed to:—

THE PRESSURE PILING COMPANY (Northern) LTD
6 WINCKLEY SQUARE, PRESTON, LANCS. *Telephone: Preston 5221*

The original and largest Bored Piling Specialists in the World

TEST BORINGS

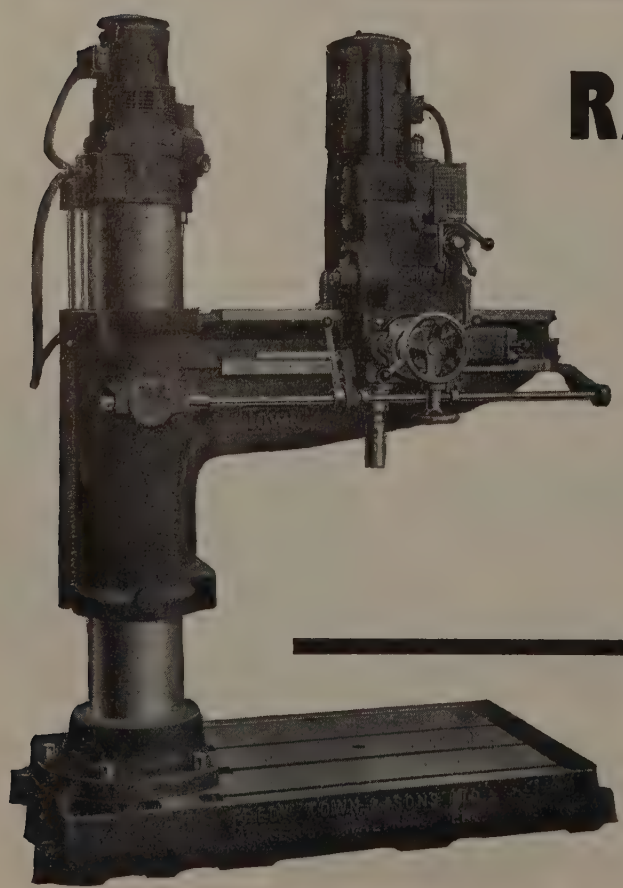
FOR THE UNDERLYING TRUTH

To ensure
THE STABILITY OF FOUNDATIONS AND EARTH WORKS

OBTAIN RELIABLE INFORMATION OF GROUND CONDITIONS

- GEOPHYSICAL SURVEYS
- SOIL SAMPLING & TESTING
- REPORTS ON GROUND CONDITIONS

GROUND EXPLORATIONS LTD
75 UXBRIDGE ROAD, EALING, W.5
Phones: EALing 1145/6 and 9251/2



TOWN
RADIAL DRILLING MACHINES

Sturdy, simple design, conveniently placed controls and maximum rates of production on the widest range of components — a few of the reasons why they are used all over the world.

Illustrated: All electric centralised control radial drilling, boring and tapping machine. Capacity 2¼ in. dia. in steel.

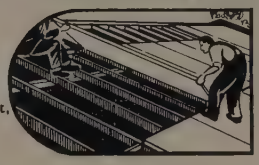
FREDERICK TOWN & SONS LTD
HALIFAX · YORKS
Established 1903

T/5

WALL-LININGS

ROOF-DECKING

Under Sheet-metal (Traditional or Patent), Asbestos, Bituminous Felt, etc.

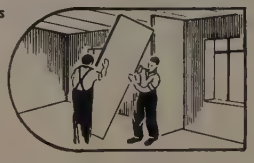


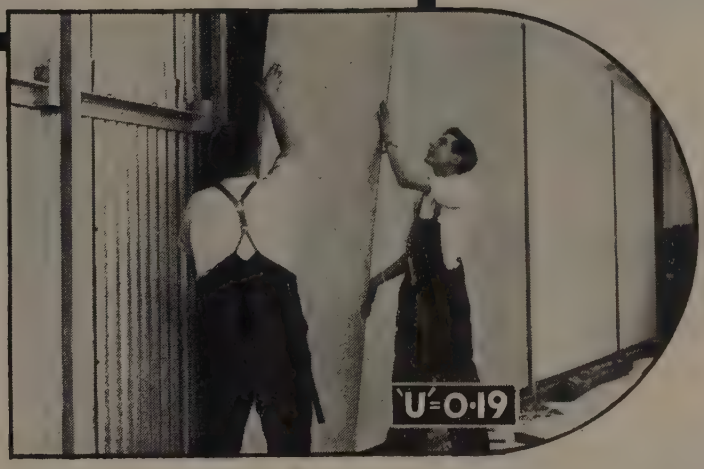
CEILINGS



PARTITIONING

- ★ Factory Screens
- ★ Divisions, etc.
- ★ Permanent or temporary
- ★ Glazed or unglazed





STRAMIT

—THE TWO-INCH THICK

BUILDING SLABS

—the low-cost dry-construction material, which combines great strength and rigidity with exceptionally good values of thermal insulation, sound absorption and fire resistance

*

THOUSANDS OF TONS ARE USED ANNUALLY IN THE CONSTRUCTION OF FACTORIES, HOSPITALS, SCHOOLS, OFFICES, FLATS AND HOUSES, THROUGHOUT THE COUNTRY

*

STOCK SIZES :
4 ft. wide x 8, 9, 10 & 12 ft. long

SPECIAL SIZES *(made to order)*:
Any width, of 4 ft. or less, and any length, greater or less than 12 ft.

NOW AVAILABLE IN

3 QUALITIES AND 3 FINISHES

—supplied through leading merchants



For latest details technical data & B.R.S. Reports

FILL IN COUPON AND POST NOW

Please send details of NEW range of STRAMIT Building Slabs:

Name of firm.....

Address.....

.....

For the attention of.....*Status*.....

STRAMIT BOARDS LTD. COWLEY PEACHEY, UXBRIDGE, MIDDLESEX

S.E. *Phone :* **West Drayton 3021**



Cooper nuts, bolts and studs are made to any specification, as regards material and dimensions.

Large stocks are carried for quick delivery.

George Cooper & Sons

PROPRIETORS THOS. W. WARD LTD.

EFFINGHAM NUT & BOLT WORKS

SHEFFIELD

'PHONE: 41026 'GRAMS: "COOPER"

c/5

OFFICIAL APPOINTMENTS

AIR MINISTRY Works Designs Branch requires in London, Structural Engineering Designer/Draughtsmen for reinforced concrete or structural steel work with sound technical training and several years varied experience in design/detailing of : (a) Reinforced concrete construction for all types of buildings, or (b) Steel framed sheds, warehouses and similar buildings. Salaries up to £790 per annum. Starting pay dependent upon age, qualifications and experience. Long term possibilities with promotion and pensionable prospects. Five day week. Three weeks three days leave a year. Normally natural born British subjects.—Write, stating age, qualifications, employment details including type of work done, to any Employment Ex change, quoting Order No. Borough 1001.

CITY OF NAIROBI. Appointment of Assistant Engineer (Structures). Applications are invited for the permanent non-established post of Assistant Engineer (Structures) in the Department of the City Engineer. Applicants should be Corporate Members of an approved Engineering Institution and preference will be given to Corporate Members of the Institution of Structural Engineers. They should have had experience in the design and checking of large steel and reinforced concrete structures. Experience with a Municipal Authority will be an advantage. The post is a pensionable one and is in the salary scale £1,606 × 50 — £2,056 per annum. The successful applicant will be required to pass a medical examination before appointment. Priority in the allocation of housing in the Council's estates is granted to married members of the staff. Application forms together with a summary of the main terms and conditions of service applicable to the appointment are available on request from the East African Office, Grand Buildings, Trafalgar Square, London, W.C.2., and from the Establishment Officer, P.O. Box 30037, Nairobi, Kenya, from both of which addresses further information may be obtained.—Applications on such forms should be addressed so as to reach the Establishment Officer, P.O. Box 30037, Nairobi, not later than Saturday, 16th February, 1957. Canvassing either directly or indirectly will result in disqualification.

LONDON COUNTY COUNCIL. Architect's Department. Vacancies for Structural Engineers in the District Surveyors' Service. Duties include checking of calculations and/or supervision of works in progress. Structural knowledge essential. Grade II (salary on scale £987 to £1,184). Grade IIIS (up to £987), and Assistants (up to £818), with starting rates according to qualifications and experience.—Particulars and application forms obtainable from the Architect (AR/EK/DS/4), County Hall, S.E.1. (2082).

LONDON COUNTY COUNCIL. Architect's Department. Vacancies for Engineering Assistant (up to £817) and Engineer Grade III (up to £987) in the Structural Engineering Division. The Division's work covers a programme of total value £12 million this year, including multi-storey flats, schools, office, warehouse and other buildings.—Particulars and application forms the Architect (AR/EK/SE/2), The County Hall, S.E.1. (15).

LONDON COUNTY COUNCIL. Architect's Department. Vacancies in the Structural Engineering Division for Resident Engineers (salary up to £987). Candidates should have B.Sc., A.M.I.C.E., or A.M.I.Struct.E., preferably with experience in supervision or reinforced concrete and/or steel-framed structures on the site, although those with adequate knowledge and experience of design alone will also be considered.—Application forms from Architect (AR/EK/RE/3), The County Hall, S.E.1. (16).

LONDON COUNTY COUNCIL. Architect's Department. Vacancies for Structural Engineers in the District Surveyors' Service. Duties include checking of calculations and/or supervision of works in progress. Structural knowledge essential. Grade IIIs (up to £987), and Assistant (up to £818), with starting rates according to qualifications and experience.—Particulars and application forms obtainable from The Architect (AR/EK/DS/4), County Hall, S.E.1. (2082).

SURREY COUNTY COUNCIL. Applications invited for following appointments : 1. Assistant Structural Engineer Grade IV, £727 15s. 0d. to £907 2s. 6d. p.a. plus £30 London Allowance. Qualified Civil or Structural Engineers experienced in design and detailing in steel and/or reinforced concrete. Ability to deal with a contract through all stages. 2. Structural Engineering Assistant Grade II, £609 17s. 6d. to £691 17s. 6d. p.a. plus L.A. up to £30 p.a. Experienced in detailing steelwork and/or reinforced concrete for medium sized buildings. Ability to design an advantage.—Full details, present salary and 3 copy testimonials to County Architect, County Hall, Kingston, as soon as possible.

CLASSIFIED ADVERTISEMENTS

SITUATIONS VACANT

AN excellent opportunity for reinforced concrete designer/detailers in Victoria Consulting Engineer's Office. Specialising in heavy industrial and civil engineering projects—five day week and excellent working conditions. Salary, bonus, promotion commensurate with ability. Box No. 0781, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

ASSISTANT Resident Engineer required for major road and bridge contract in London area. Experience of reinforced and prestressed concrete bridge construction, earthworks and concrete roads advantageous. Salary up to £1,200 per annum.—Write, stating age, qualifications and details of experience, Harry Brompton, Consulting Engineer, 7, Hobart Place, Westminster, S.W.1.

CIVIL ENGINEERING AND STRUCTURAL DRAUGHTSMEN

Imperial Chemical Industries Limited, General Chemicals Division, requires CIVIL AND STRUCTURAL DRAUGHTSMEN for an extensive Programme of capital construction to assist in the design of plant structures and services for large chemical plants and power stations. Applications are invited from men who hold at least an Ordinary National Certificate in Civil and Structural Engineering and who have a good knowledge of steel or reinforced concrete structure design. Experience in plant or power station work would be an advantage but is not essential. The vacancies exist in the Chief Engineers Department at Runcorn, Cheshire. Pension Fund and Profit-Sharing Schemes. The company can give limited assistance to married men in the matter of house purchase and removal expenses.—Applicants should write, (Quoting CESD4) stating age, experience, qualifications and salary required to

STAFF MANAGER,
IMPERIAL CHEMICAL INDUSTRIES LIMITED,
GENERAL CHEMICAL DIVISION,
CUNARD BUILDING,
LIVERPOOL, 3.

CONSULTING Engineers require Reinforced Concrete and Steelwork Designers and Designer Draughtsmen for varied interesting and responsible work in London. Several years' experience and ability to work without supervision essential. Salary from £750 p.a. according to age and experience.—Apply Sir Bruce White, Wolfe Barry & Partners, 1, Lygon Place, Grosvenor Gardens, S.W.1. Tel.: Sloane 0431.

EXPERIENCED R.C. Detailers required for interesting and varied work with a large firm of Building and Civil Engineering Contractors. 5½ day week. Canteen facilities.—Applying giving full details of experience, age and salary required. Box No. 0776, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

CIVIL ENGINEERS

Fine opportunities in engineering await the right man—the man who is **properly qualified.** The decision to acquire the knowledge you need is up to you alone—but you don't have to be alone in the way you go about it. Let I.C.S.—the world's largest and most successful correspondence school—give you the specialised training that will make yours a career of achievement.

I.C.S. FACILITIES INCLUDE

- **Courses of instruction in most branches of engineering.**
- **Guaranteed coaching for I.Struct.E., I.C.E., I.Mun.E., etc.**
- **Specially prepared, up-to-date and comprehensive instruction manuals.**
- **Highly qualified instructors versed in practical as well as theoretical engineering.**
- **Moderate fees—inclusive of all necessary books.**
- **Study in your own time, at your own pace.**

WRITE FOR FULL DETAILS TODAY

Please send free booklet on.....

NAME..... AGE.....
(BLOCK LETTERS PLEASE)

ADDRESS .....

OCCUPATION .....

INTERNATIONAL CORRESPONDENCE SCHOOLS, Dept. 249A
International Buildings, Kingsway, London. WC2.
2/57

Opportunity for Reinforced Concrete Designers . . .

to join the London staff of BRC

There are opportunities for Reinforced Concrete Designers in their New London Office at 54 Grosvenor Street, equipped with controlled heating and ventilation and canteen.
Five day week — 37½ hours — Pension Fund.
Salaries are reviewed annually.
Designer-Detailers with good experience will be offered salaries of £750 to £950 per annum, and Detailers with some design experience, up to £750 per annum.
They also have a few openings for Student Apprentices of good educational standard and for Students who have just completed the Higher National Certificate Course.

THE BRITISH REINFORCED CONCRETE ENGINEERING CO. LTD
STAFFORD
Chief Engineer: A. P. MASON, B.Sc., M.I.C.E., M.I.Struct.E., M.ASCE

M-W.809R

REINFORCED Concrete Detailing Draughtsmen required for interesting and varied work. Five day week. L.V.—Please write, stating age, experience and salary required to F. J. Samuely 8, Hamilton Place, W.1.

CLASSIFIED ADVERTISEMENTS—continued.

REINFORCED Concrete Designer for work in Victoria Street, London. Five-day week, non-contributory pensions scheme after three years' service; progressive position; five years or more experience with R.C. specialists preferred.—Write giving full particulars to The Spencer Wire Co. (Developments) Ltd., 53, Victoria Street, London, S.W.1.

SENIOR Reinforced Concrete Designers wanted for leading R.C. Engineers and Contractors. Must be fully conversant with Code of Practice, L.C.C. Bye-Laws, and able to design light framed structures from estimating stage to final details. Five-day week. Pension scheme. Progressive position. Starting salary from £900 upwards according to ability. Juniors also required, similar conditions.—Write Box No. 0627, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

SENIOR Structural Engineer in Newcastle required by growing firm of Consulting Engineers. Applicants preferably over 35 years old and experienced in design and site supervision of foundations and framework in both steel and reinforced concrete. Duties will involve visiting sites and advising Architects in North East England. Four figure salary.—Send full particulars and salary required in confidence to Alan Marshall & Partners, 115, Gloucester Place, London, W.1.

STRUCTURAL Engineer required for Contract in the Lebanon to supervise erection of large Steel Hangars. Liberal salary and allowances to right applicant.—Write Box No. 608, Willings, 362, Grays Inn Road, W.C.1.

STRUCTURAL Designer required for London office responsible for building schemes of all types in all materials. The position offers a wide experience to a man able to work on own initiative with some supervision. Salary up to £950 per annum. Box No. 0790, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

STRUCTURAL Engineer required to take charge of Drawing Office in Southern Counties. Only fully qualified men should apply whose experience covers all classes of R.C. design and prestressed concrete. Applicants should be between 35 and 45 years of age. Salary will be not less than £2,500 per annum, with prospects of yearly increases and a seat on the Board of the company in due course. All applications will be treated in the strictest confidence. Box No. 0791, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

STRUCTURAL Designer age 25—30 years. Experience in R.C. structure and with knowledge of steelwork. A.M.I.Struct.E. preferred. Structural Draughtsman age 21—25 years. Experience in steel or concrete structures. Graduate or Student I. Struct.E. preferred. Both positions are permanent and provide opportunity for varied and interesting experience on design and construction of modern buildings. 5 day week. Good Salary.—Write giving full details and salary required to Monro & Partners, Architects & Engineers, 32, Clarendon Road, Watford, Herts.

STRUCTURAL Engineers required by Consulting Engineers engaged upon the design and foundations and superstructures of industrial buildings, hospitals, offices and other interesting works in both Reinforced Concrete and Steel. Pay according to experience but not less than £750 p.a. to suitable applicants. Superannuation scheme and Luncheon Vouchers.—Apply Andrews, Kent & Stone, 60, Wardour Street, W.1.

STRUCTURAL Engineering Designer-Detailers are required by Scott & Wilson, Kirkpatrick & Partners, Consulting Engineers, 47, Victoria Street, Westminster, S.W.1. for appointments in the London Office on important structural steelwork and concrete Works. Candidates must have at least three years' sound experience in designing and/or detailing welded and riveted steelwork or reinforced (including prestressed) concrete. They should preferably be Graduates or Associate Members of The Institution of Structural Engineers. Starting salaries will be graded according to age and experience. Luncheon vouchers, pension scheme and five-day week pertain to the appointments which carry good prospects. Applicants are invited to write in confidence to the above address, stating age, professional qualifications and full details of experience.

THE TRUSSED CONCRETE STEEL Co. Ltd. have vacancies in their London, Harlow, Glasgow, Birmingham and Manchester Offices for REINFORCED CONCRETE DESIGNERS AND DETAILERS. Five-day week. Pension scheme.—Apply giving full particulars of age, education and previous experience to the Engineering Manager, Truscon House, 35-41, Lower Marsh, London, S.E.1.

CHANGE OF ADDRESS

MESSRS. Taylor, Whalley & Spyra, Consulting Civil Engineers, are moving from their London Office, 20, Dorset Square, N.W.1., on the 17th December, 1956. Their new address is 24, Harley-Street, W.1., telephone No. Langham 0172/3.

BUSINESS PREMISES

N.W. LONDON. Prom. Corner Offices. 9 Light Rooms. 2,000 sq. ft. Comp. Redec. Low Rent. Moss & Partners, 15, South Molton Street, W.1. MAY/9933.

TUITION

CIVIL ENGINEERING. Guaranteed Coaching for Inst. Struct. Engrs., Inst. Civ. Engrs., Inst. Mun. Engrs., etc. Study at home under highly qualified tutors with most successful school. Also courses in all aspects of Building, Engineering, Draughtsmanship, etc.—Write for free book: International Correspondence Schools Ltd., Dept. CL., 23, Kingsway, London, W.C.2.

FOR HIRE

LATTICE Steel Erection Masts (light and heavy), 30 ft. to 150 ft. high for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone: SLOane 5259.)

THEODOLITE REQUIRED

THEODOLITE required. State age, type, condition, price required. John Knox (Bristol) Ltd., Winterstoke Road, Bristol, 3.

TECHNICAL PUBLICATIONS REQUIRED

WANTED, pre-1955 issues of Geotechnique. Contact J. C. Stewart, 125, Harbourne Road, Birmingham, 15.

INDEX TO ADVERTISERS

A.C.E. Machinery Limited 38
Associated Lead Manufacturers Export Co. Ltd. 35
Braithwaite & Co. (Engineers) Ltd. 15
British Columbia Lumber Man. Assoc. .. 14
British Constructional Steelwork Assoc. .. 1
British Reinforced Concrete Eng. Co. Ltd., The Cover iv
Butterley Co. Ltd The 24
Cement Marketing Co. Ltd. 20
Cementation Co. Ltd., The 34
Concrete Piling Ltd. 3
Cooper George & Sons 44
Costain Concrete Ltd. 29
Dawnay's Ltd. 22
Demolition & Construction Co. Ltd 37
Dickens Stuart B. Ltd. .. .. .. Cover ii
Dorman Long Ltd. 17
Ellis, James W. & Co. Ltd. 12
Farmer, S. W. & Son Ltd. 10
Fibregass Ltd. 4
Fisher & Ludlow Ltd. 7
Franki Compressed Pile Co. Ltd. 39
Ground Explorations Ltd. 42
Hawksley SMD 31
Heywood, W. H. & Co. Ltd. 11
Hill, Richard Ltd. 6
International Correspondence Schools 45
Jasons (Equipment) Ltd. 10
Johnson, Richard & Nephew Ltd. 30
Jones, T. C. & Co. Ltd. .. .. 8 & 9
Kennedy, Allan & Co. Ltd. 16
Ketton Cement .. .. Cover iii
Lafarge Aluminous Cement Co. Ltd. 25
Laing, John & Sons Ltd. 23
Limestone Federation, The 18
Lind, Peter & Co. Ltd. 26
McCall (Sheffield) Ltd. 40
Murex Welding Processes Ltd. 32
Pressure Piling 41
Pynford Co. Ltd. 34
Redpath Brown & Co. Ltd. 5
Rubery Owen & Co. Ltd. 33
Simplex Concrete Piles Ltd. 32
Smiths Fireproof Floors Ltd. 38
Sommerfelds Ltd. 28
South Durham Steel & Iron Co. Ltd. .. 21
Stent Precast Concrete Ltd. 36
Stramit Boards Ltd. 43
Town, Frederick & Co. Ltd. 42
United Steel Co. Ltd. 19
Walker Bros. Ltd. 2
Wests Piling & Construction Co. Ltd. .. 13
Westwood, Joseph & Co. Ltd. 36
Yorkshire Hennebique Construction Co. Ltd., The 40

for

SUPERIOR CONCRETE

KETTON CEMENT



Sole Distributors :
THOS. W. WARD LTD., ALBION WORKS, SHEFFIELD

K.15



Within the slab...

Welded Fabric

the ideal reinforcement for all types of slab construction for roads or floors whether on the ground or suspended. BRC fabric is a welded steel wire mesh supplied in sheets or rolls.

THE BRITISH REINFORCED CONCRETE ENGINEERING CO. LTD., STAFFORD

London, Birmingham, Bristol, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast

Export Dept., 54 Grosvenor Street, London, W.1

M-W.833